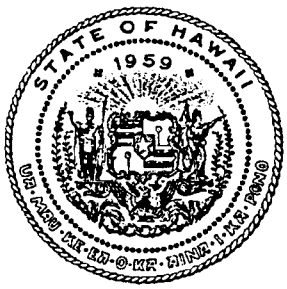
AN ASSESSMENT OF AVAILABLE INFORMATION ON THE IMPACT OF GILLNETTING IN STATE WATERS AND PROPOSED MEASURES TO REGULATE THE USE OF GILLNETS



Prepared by

Department of Land and Natural Resources
State of Hawaii

in response to

House Concurrent Resolution No. 421, House Draft 1
Sixteenth Legislature, 1992 Session

Honolulu, Hawaii
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CONTENTS

EXECUTIVE SUMMARY

Available information on the impacts of gillnet fishing in Hawaiian waters is presented for consideration, in response to House Concurrent Resolution No.421, House Draft 1 of the Sixteenth Legislature 1992. Gillnetting is a widespread activity in Hawaii, popular among both recreational and commercial fishers. Fishing ("creel") surveys at Waikiki and Kaneohe Bay, Oahu, and Hilo Harbor Fisheries Management Area (FMA), on the Big Island, show that restricting the use of gillnets and other fishing gears with high catch rates can dramatically improve localize fish abundances.

Gillnets are an extremely efficient fishing gear that can harvest large numbers of fish, especially when long gillnets (over 500 ft) are set overnight in inland waters. Although some size selection is possible, fishers have limited control over the species and sizes caught. When left for long periods of time, particularly overnight, gillnets cause drowning of threatened and endangered sea turtles and many of the fish caught are either spoiled or eaten by predators.

Present regulations of gillnet fishing allow nets to be left unattended for periods up to twelve hours and net meshes to be as small as two inches. These measures result in excessive fishing mortality, waste of fish captured and adverse impacts on species not targeted by fishers. Therefore, this report recommends:

1. Immediate measures to limit the time a net may be left unattended to two hours.

2. Guidelines for the gradual development of well-defined regional closures in selected areas throughout the State, to protect inshore feeding and nursery areas.

3. Minimum mesh size be increased to between 2¾-3 inches. The exact mesh size should be determined and implemented over a 1-2 year period.

4. Guidelines to develop a system to permit and label all gillnets with a visible marker, and identify net owners, so that regulations limiting the amount of time a net may be fished to somewhere between 2-4 hours can eventually be implemented.

While restriction of gillnet fishing in State waters may be warranted, restrictive measures will be more effective if developed on a regional basis. Ecological and region-specific differences in fish abundance and fishing activity should be addressed on a local level, and the public fully involved in the development of acceptable management measures in an open forum of discussion, information and consensus building. A three-phase plan is described in this report that will allow the gradual development of measures that will protect inshore resources from overharvesting, while allowing a moderate amount of gillnet fishing to take place in a manner that is less detrimental to marine resources.

November, 1992

REPORT ON HOUSE CONCURRENT RESOLUTION NO. 421, HOUSE DRAFT 1

URGING THE DEPARTMENT OF LAND AND NATURAL RESOURCES TO ASSESS THE IMPACT OF GILLNETTING IN STATE WATERS AND PROPOSE REGULATIONS TO CONTROL OR RESTRICT THE USE OF GILLNETS.

I. PURPOSE OF THE REPORT

This report is submitted in compliance with H.C.R. No. 421, H.D. 1, adopted by the Sixteenth Legislature of the State of Hawaii, Regular Session of 1992 (Attachment 1). The Concurrent Resolution requests that the Department of Land and Natural Resources (DLNR) prepare a report on the use of gillnetting in State waters which will include, but not be limited to:

(1) An assessment of the impact of nearshore gillnetting on Hawaii's fishery;

(2) Recommendations on the adoption of new or alternative rules or regulations, if needed, which would mitigate the impact on nearshore fishery resources, such as changing the eye mesh size of gillnets, the overall length of such nets, and the duration of time for which the nets may be left unattended; or

(3) Proposed enabling legislation, if necessary, to regulate, control, or restrict the use of gillnets.

H.C.R. No. 421, H.D.1 further resolved that the DLNR would submit its findings and recommendations to the Legislature no later than twenty days prior to the convening of the Regular Session of 1993.

II. BACKGROUND

Gillnets are widely used throughout Hawaii, and gillnetting has long been a topic of legislative concern. Almost every year over the last decade, one or more bills have been introduced proposing regulatory measures for gillnets. These bills have provoked lively debate, but have not passed legislative review for one reason or another. Much of the disagreement stems from the lack of information on gillnetting, its use and impacts on inshore resources throughout the State. Thus, H.C.R. 421, H.D.1 requested that the most complete information available be compiled for consideration.

The Department indicated in their testimony on this resolution before the House Committee on Ocean and Marine Resources that gillnets are a very effective fishing method, capable of reducing the abundance of reef and nearshore fisheries. Available data were presented in favor of House Bill 38, a measure designed to limit the use of gillnets in inshore areas, which was considered concurrently with H.C.R.421. These data and other information regarding gillnet fishing will be discussed and put into perspective in the following report.

No funding was provided specific to this study; however, an effort has been made to draw upon information compiled through existing programs to address H.C.R.421 to the extent possible with the resources available.

A. Existing Rules:

Existing rules governing the use of gillnets in Hawaiian waters should be noted. There are two statutes with regard to nets and traps that apply to gillnets.

Hawaii Revised Statutes §188-29. **Nets and traps** states:

> (a) "It is **unlawful** for any person **to use nets** [or traps] **made of or using netting** [including] or bullpen traps [of any type] **with a stretched mesh of less than two inches...**"

Applicable exceptions to HRS §188-29(a) include:

> "(6) All persons may use a net with mesh of not less than 1½ inches to take akule; provided that no akule measuring less than 8½ inches in total length ... shall be taken with a net during the months of July, August, September, and October; and
>
> (7) All persons engaged in surround net fishing with scuba may use nets with mesh of not less than 1½ inches only to bag and transport the fish captured with legal gear to the shore or the boat..."

In addition, HRS §188-30.2. states:

> "**Fishing with gill nets.** It is unlawful for any person engaged in gill net fishing to leave the person's net unattended for a period of more than twelve hours."

B. A Definition of Gillnets and Fishing Methods

As a basis for discussion, it is important to clarify terminology regarding gillnetting and related forms of net fishing. Issues regarding specific methods have arisen during discussion of the regulation of gillnet fishing. A review of legislative and public debate shows underlying differences in perceptions of what constitutes gillnetting. To be interpretable, regulations must specify completely and unambiguously the gear and methods to which they apply. Therefore, this report begins with a description of gillnetting and related fishing methods.

Fishing gears are defined both by their construction and the way they are meant to catch. The ordinary gillnet consists of a single wall of webbing[1], connected to a cork (float) line at the top and a lead (sink) line at the bottom. The gillnet hangs vertically in the water by means of these floats and sinkers. Usually a buoy and marker of some sort is attached to the (nylon) float line at one end, to identify the net and assist fishers in relocating it when it is retrieved. Some form of anchor is also placed at either or both end(s) of the lead line to keep the net from moving in the current. Depending on the length of the anchor and float lines and ratio of floats to sinkers, the net can be made to fish at the surface, in mid-water or on the bottom.

Fish are captured in a gillnet by the mesh of the net, in trying to swim through. If the mesh is the correct size for the fish sought, it will be able to get its head through, but not its whole body. When it tries to back out, the twine of the mesh slips under the gill cover preventing escape. Fish that are too large to get the head in or are small enough to swim through are not captured, unless they are entangled by their fins or other bony projections on their bodies. This size-selectivity of the mesh is used by fishers to target sizes and types of fishes, although the fishers' control of species composition is limited. The location, time of day, placement and material of which a gillnet is constructed also help determine species and size composition of the catch. Gillnets are made of a variety of materials, including cotton, linen and nylon, but the most popular modern material is a translucent monofilament (plastic) line. The line varies in thickness, transparency and strength, depending on the fish targeted. The mesh sizes generally sold in Hawaii vary from 2" to 3" (stretched mesh), but most gillnet fishers prefer a 2¾-3" mesh. A 1¾ " mesh is usually used in fence or bag nets (typically made of nylon).

A suite of gears and fishing methods are found in Hawaii which can generally be classed as gillnetting. The way these gears are constructed is summarized in Table 1, with information on the species targeted, inshore areas fished, times of day and a general description of each fishing method. For completeness, related net fishing methods are included in the table (below the bold black line). These are not considered gillnetting, because the fish are caught primarily by encircling. However, in some cases the gear itself is similar and it is the way it is used that distinguishes the method. This must be understood in developing regulations for gillnet fisheries. Hawaii is one of the few places in the United States where gillnets are used to surround schools of fish. There are several other unique ways that gillnets are used in Hawaii. Some of the proposed exceptions to gillnet regulations over the past few years have been based on these unique features.

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[1] Double-layered gillnets (crossnets) are also occasionally used in Hawaiian waters.

TABLE 1: A SUMMARY OF GILLNET AND RELATED FISHING METHODS

Name Net/ Method	Species Targeted	NET CONSTRUCTION				Depth fished (ft)	Area and Distance from Shore Fished	Attended? How often?	Time of Day	Description of Fishing Method
		Material	Mesh Size (inches)	Depth (ft)	Length (ft)					
Gillnet: Pocket or Mullet Net	Mullet	Monofilament	3	20	250-750	7-20 (depth of the water)	Generally within the reef or in a bay	Yes Always	Daylight (anytime until sunset)	Drop net in front of school spotted from boat. Either unite net panels end-to-end to surround, leading fish into a pocket (where they are trapped); or break into smaller 250-500ft pieces in various locations to gill.
Gillnet	Reef: Menpachi, Uhu, Weke	Monofilament	2½-2¾	7	1000-1500	10-20	Inside to right outside reef	Yes	Evenings & early morning before sunrise	Set from boat. Fish 3-4 hours at a time (tending net constantly).
Gillnet: Floating/Drape	Mullet,Omaka, Akule,Paplo	Monofilament	2¾	18-20	less than 1200	30	Embayments and estuaries	Yes	As above	As above, but net fishes at the surface.
Gillnet: Palpal Method	Reef: Kala, Palani, Weke	Monofilament	4-6 for surgeons; 2 for weke	7-30	less than 1000	7-30 Net covers water depth	Alongside reef	Yes	Daytime	Spot fish from boat and verify by diving underwater. Chase fish into net by paddle or body movements. Fish are gilled.
Gillnet: Moi moi Method	Mullet and various others	Monofilament	2½-3	7	1200-3000	Variable, from 2-3ft to 60-70ft	Try to stay away from inshore area, depending on fish movement. Usually inside a barrier reef or bay, but outside innermost fringing reef.	Yes. Leave 2-3hrs at a time. Fisher usually in boat, near net at all times.	½hr before to right after sunrise; or ½hr before sunset to 10-11pm; or sunset to right before dawn.	Lay net on sandy portions adjacent to reef. Pickup within 2-3 hours. Generally fish once a night. or Set overnight along reef. In both cases, fish are gilled. No surrounding.
Gillnet: Crossnet/Skirt	Various mostly reef: Palani, Nenue, Manini, Ahólehóle, Menpachi Akule	Monofilament	2½-4	4-12	50-1000	Along rocks or in path of fish movement	Set beside reef, along rocky coast. Sometimes in path of fish movements or across entrance to cove	Depends: May palpal, may tend, or set overnight for fish like menpachi	Day or Night	Distinguished from other gillnets by the double layers of netting. Similar to a trammel net; differs by smaller meshes, double (vs. triple) panels, and the way it is set primarily to gill fish. Panels may have different mesh sizes, entrapping both large and small fish by gilling or entangling. Just becoming established in Hawaii and has high potential negative impact.
Huklau	Various nearshore species	Cotton Ti leaf skirt (Modern) Monofilament	2	7-12	250-1000	Less than 12ft	Within fairly close swimming distance of shore; in areas with a beach.	Yes. At all times.	Daylight or right before sunset.	The net is used much like a beach seine. A large number of people swim the net out and encircle a school or group of fish, bring the ends to shore in a "U" shape, then pull in the bag from shore.
MOST AKULE FISHERS USE TWO TYPES: 1)Surround/Fence	Akule Paplo Weke	Nylon	1½	40	1250-5000	Not deeper than 40ft; Usually less than 20ft.	Right outside reef over fairly shallow sandy areas	Yes Always	Daylight (net sometimes out overnight)	Spot fish from plane, boats or mountain top. Surround school (or part of it). Method varies: may encircle (coil) about a 50 yd. perimeter in a snail shape and slowly tighten, or close immediately and pull bag.
2) Gillnet		Monofilament	2½-2¾ (2 during hahalalu)	7-30	625-4000				Daylight (nets in and out in 1hr.)	Fish spotted and netted much as above. Total length of both gill & fence nets used to surround vary based on fish movement, size and depth of area fished.
Fence	Any kind	Nylon or cotton	2-4½ wings to 1½ in bag	10-30	200-2000	10-120	Outside reef, usually in deep water	Yes Always	Daylight	Circle a school of fish from the boat. No gilling. Bag huge(10x10x30ft).Net on bottom; water quite deep.
Buckle Trammel net Pocket	Any kind	Monofilament	6½ wings to 2¾	7-12	2000	8-20	About 100yd from shore (in or outside the reef)	Yes	5-8pm to before 12am	Set net so wings guide fish into the bag. Note: these are triple-panel nets; fish are ensnared between panels, gilled and bagged.
Tangle net Lobster net	Lobster Kona crab	Multi-filament Nylon	6	3	50-600	Less than 20ft.	Adjacent to fringing reef or rocky areas	No. Set daily p/u morning	Overnight	The net is set in shallow water, near rocky crevices or reefs. Lobsters caught by entangling legs.
Opelu net (circle net)	Opelu	Nylon	1	7-30	40	7-30	Anywhere over 50ft.	Yes Always	Daytime very few night	The school is spotted from a boat, plane or high spot; then encircled & bagged over shallow sandy bottom.

III. STUDY AND EVALUATION

A. Assessment: Impact of Nearshore Gillnetting on the Fishery

No specific study to assess the impact of nearshore gillnetting on Hawaii's fishery could be conducted, given the aforementioned funding limitations. Two types of information would be needed for such an assessment: 1) estimates of the catch and resulting fishing mortality due to this gear, and 2) estimates of the size of the resource and amount of catch (or mortality) it can support without jeopardizing its sustainability. For the first part of this assessment, estimates of the number of nets fished, their size (mesh size, length, depth), average length of time and how often fished, catch composition and catch rates (i.e. length, weight and number of fish per hour or day) by species and region around the Hawaiian Islands would be needed. For the second part, an estimate of the amount of inshore resources in the areas fished (weight or numbers by species), and their turnover rates (growth, reproduction and combined fishing and/or natural mortality sustained by these resources) is needed. If harvest rates do not exceed population size, growth and mortality (from all forms of fishing, predation and natural death), a viable fishery can be maintained.

An assessment of the impact of gillnetting should take into account the impacts of all fishing gears and methods which affect the same resources, as well as regional differences in fish stocks and fishing pressure. This would make it possible to balance the impact of gillnetting against those of other fisheries. A number of management scenarios can be developed for any fishery. Once favorable options are understood, choices can be made based on the costs, benefits, acceptability and enforceability of each. This process involves agency, public and legislative discussion, review and compromise.

Fishing is an activity of recreational, subsistence and economic benefit to the people of Hawaii. It is also a way of life that is part of the cultural heritage of Hawaiian residents of all ages and ethnic backgrounds. Therefore, limitation of fishing activity should be based on a determination that such restriction is necessary to protect natural resources from overharvesting. Biological assessments are one way of arriving at such a decision. However, reliable methods take considerable time and effort, and each has it's own margin of error. The fishery may reach the point where its recovery is slow or improbable while accurate information is being obtained. Regulations to prevent overharvesting can often be developed more rapidly via informed public consensus.

In the absence of sufficient time and funding to complete a comprehensive study of the fishery, a discussion of the salient features of gillnetting in Hawaiian waters is presented based on available data. While it is limited in scope, this information does allow some immediate recommendations to be made and provides a basis for the development of longterm solutions. The information presented has been obtained from several sources, including: 1) ongoing biological studies in existing Fishery Management Areas (FMAs), Marine Life Conservation Districts (MLCDs), and other coastal areas, 2) public meetings, 3) a review of proposed regulations and testimony regarding gillnetting presented to the Legislature over the past three years, 4) interviews with gillnet fishers on the islands of Oahu, Hawaii and Kauai, and 5) discussions with DLNR's enforcement officers (Division of Conservation and Resources Enforcement, DOCARE).

1 Ongoing Studies in FMAs, MLCDs and other Coastal Areas:

a. Summary 1978-1992 Findings: Waikiki-Diamond Head Shoreline FMA/MLCD Complex

While it is difficult to estimate the impacts of fishing on resource abundance by monitoring catch and effort, the impacts can be evaluated indirectly by monitoring changes in abundance in areas where fishing is restricted in one way or another. If all other factors remain constant, localized changes in diversity and abundance of non-migratory species can be attributed to differences in management measures. Studies by the Division of Aquatic Resources (DAR) aquatic biologists in the Waikiki-Diamond Head Shoreline FMA demonstrate the combined impacts of fishing by gillnets, surroundnets, throwets, scoopnets and spears. However, the impact of gillnets alone in this area can only be inferred.

On July 1, 1978, the State's first shoreline FMA was established. Regulation 45 (now Hawaii Administrative Rules Chapter 13-48) banned all fishing activities for two years along a two-mile shoreline area, from the Kapahulu Groin to the Diamond Head Lighthouse. The restricted area extended 500 yards offshore and encompassed the fringing reef. A rotating four-year management cycle was implemented. For ten years thereafter, the area was closed to all methods of fishing every other two years. Following each two-year closed period, the area was opened to pole-and-line or hand harvesting methods only for one year (third year of the cycle). Fishing methods excluded in these periods include throwets, spears, scoopnets, gillnets and surround methods. During the second "open" year (fourth year of the cycle), all legal fishing methods were allowed. Then another two-year closed period would begin.

1) Dive Surveys

Monthly dive surveys were made in the Waikiki-Diamond Head FMA, from 1978 throughout most of 1988. DAR divers swam a series of transects, over the entire FMA, and visually estimated the number of fish by species. These surveys provided an index of abundance (number of fish/acre) and diversity (number of species). Biomass (lbs of fish/per acre) estimates were based on species specific length-weight relationships and fish numbers.

Figure 1 summarizes annual changes in average biomass and abundance observed from 1978-1988, versus management measures in effect. Means were calculated with a three-month time lag from the beginning of each fiscal year (when management changes took place), because it takes a few months for changes in fishing practices to affect fish abundance. Annual means of abundance, biomass and number of species registered are summarized in Appendix 1, with their standard deviation as an index of variability.

Estimated fish abundance, biomass and diversity increased during years when no fishing was allowed, and declined when fishing resumed. The greatest resource recovery was always observed during the second year without fishing. Abundance, biomass and diversity declined continuously following the closed periods, although only pole and line or hand fishing methods were allowed during the first "open" year of each management cycle.

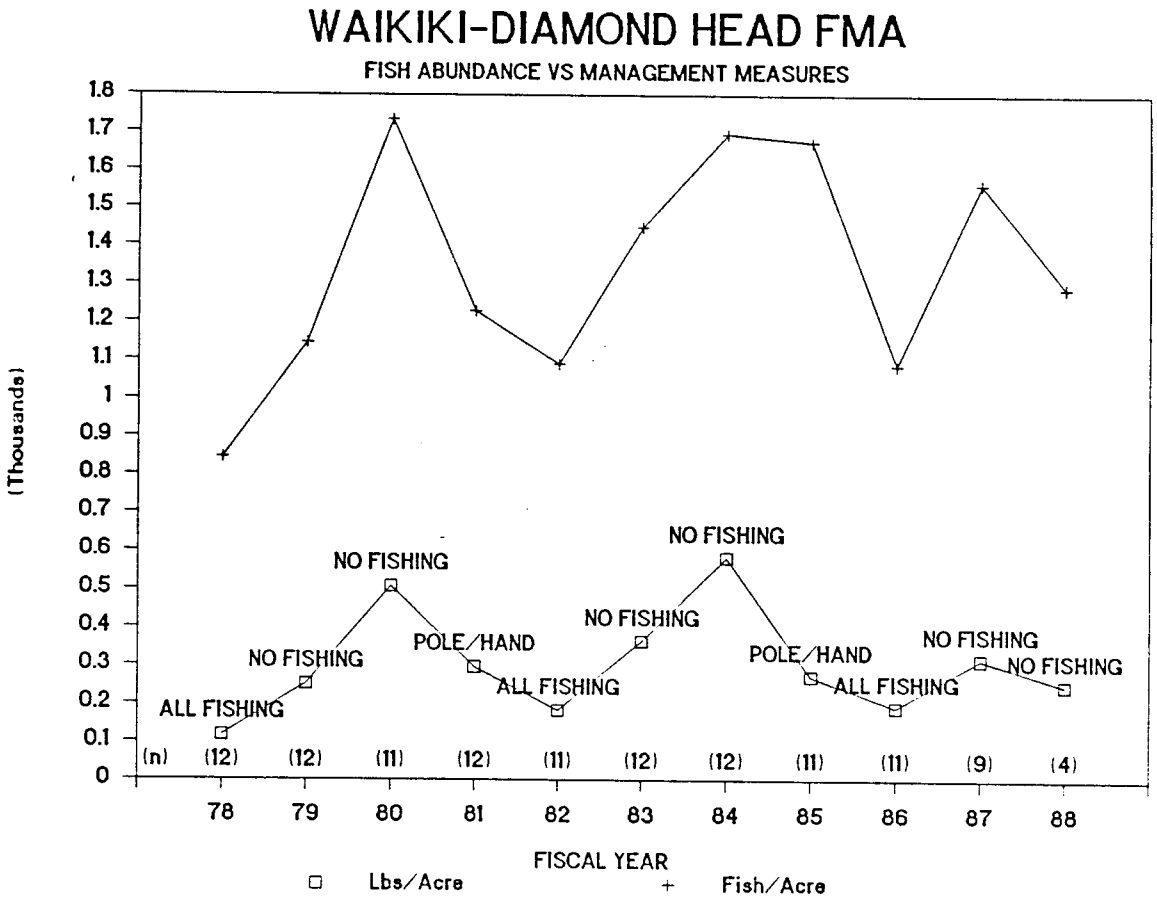

WAIKIKI-DIAMOND HEAD FMA
FISH ABUNDANCE VS MANAGEMENT MEASURES
(Thousands)
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
ALL FISHING
NO FISHING
NO FISHING
POLE/HAND
ALL FISHING
NO FISHING
NO FISHING
POLE/HAND
ALL FISHING
NO FISHING
NO FISHING
(n) (12) (12) (11) (12) (11) (12) (12) (11) (11) (9) (4)
78 79 80 81 82 83 84 85 86 87 88
FISCAL YEAR
Lbs/Acre
Fish/Acre

FIGURE 1

While the FMA was quite successful in restoring fish abundance, observed changes are not attributable solely to the restriction of gillnets; several other fishing methods were also restricted (both during "no fishing" and "pole/hand" periods). Furthermore, biomass and abundance estimates were quite variable, as shown by the high standard deviations relative to annual means (Appendix 1). Variation in fish counts due to differences in seasonal and diurnal cycles may contribute to overall variability in dive survey estimates. Overall trends are considered reliable since the same areas were surveyed each year and the number of monthly surveys was similar in most years.

2) Fishing Surveys

Fishing ("creel") surveys were also conducted in the Waikiki-Diamond Head FMA during the "open to fishing" periods between 1978 and 1988. Creel surveys are an increasingly popular way to get information regarding fishing catch and effort, by actively seeking out fishers and interviewing them in the field. Accurate information on the number of fish caught is difficult to obtain through passive data collection systems, such as the Fish Catch Reports required of Hawaii's commercial fishers. Since only commercial fishers are required to report, Commercial Catch Reports do not provide a complete picture of fishing activity.

Table 2 summarizes data from creel surveys conducted during the open years at the Waikiki-Diamond Head FMA. DAR (student) fishery aides interviewed a variable number of fishers each year, primarily on weekends and afternoons. Although there are some limitations in interpretation of the data collected, useful information on catch rates and species composition of the catch was obtained in this manner. However, the continuity of creel survey data is interrupted by "closed to fishing" cycles, since interviews can only be conducted when fishing is taking place. Thus, the importance of having a fishery-independent sampling method (such as dive surveys) must be noted.

TABLE 2: RESULTS OF CREEL SURVEYS DURING "OPEN TO FISHING" PERIODS AT THE ORIGINAL WAIKIKI-DIAMOND HEAD FMA

YR	No. Inter-views	No. Fishers	No. Fish Caught	OVER-ALL CPUE (Fish/ Fisher)	CPUE: HOURLY CATCH RATE[2] BY GEARTYPE						
					Pole & Line	Spear	Scoop Net	Gillnet	Surround	Thrownet	Hand
81	1473	2757	4397	1.59	0.6	—	—	—	—	—	0.6
82	633	1116	4565	4.09	0.4	1.3	6.0	1.4	3.8	7.3	0.9
85	1456	2352	1745	0.74	0.2	1.0	—	—	—	—	0.6
86	371	805	6769	8.41	0.4	0.9	1.9	2.0	2.4	2.5	3.7

[2] NOTE: **HOURLY CATCH RATE UNITS** are in
fish per line-hr for Pole & Line (Rod & Reel),
fish per man-hr for Spear, Scoopnet and Handpick methods, and
fish per net-unit-hr for Gillnet and Surroundnet (125ft net-unit)
or Thrownet (circular net-unit).

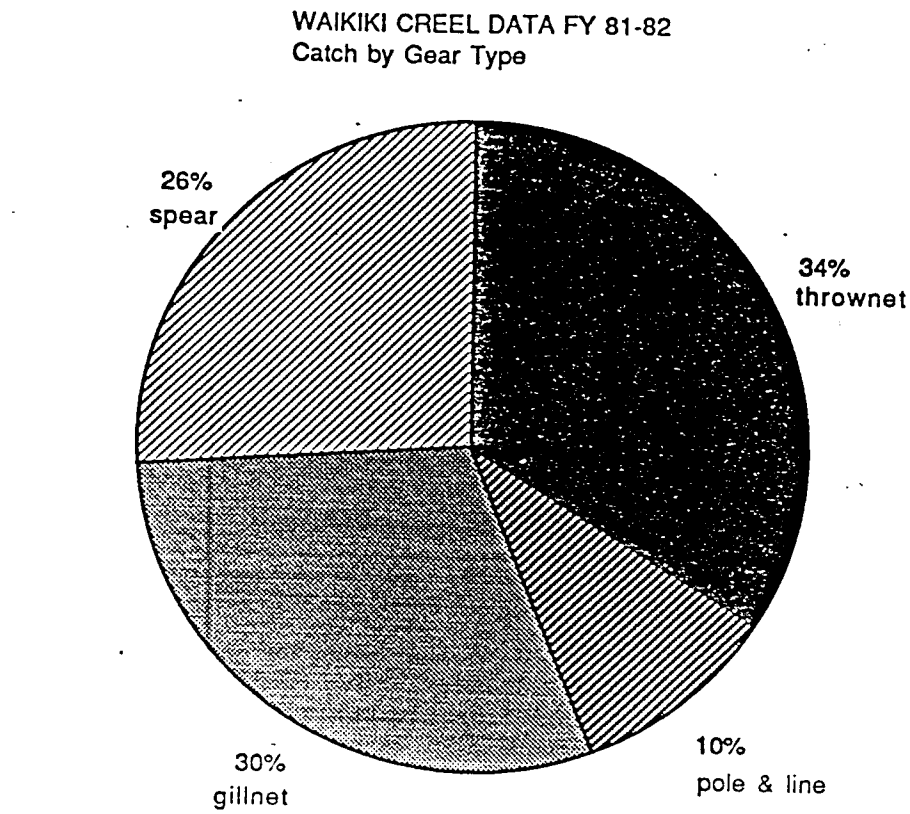
Overall catch rates (the total number of fish caught divided by the number of fishers interviewed) summarized in Table 2 show general trends in harvest of the FMA. This simple index demonstrates the increased harvest rate per fisher during years when all fishing methods were allowed. These increases were due to the use of gears with high catch rates, such as gillnets, surroundnets and thrownets. It was based on this observation that the FMA rules were later modified to prohibit some of these gears on a permanent basis.

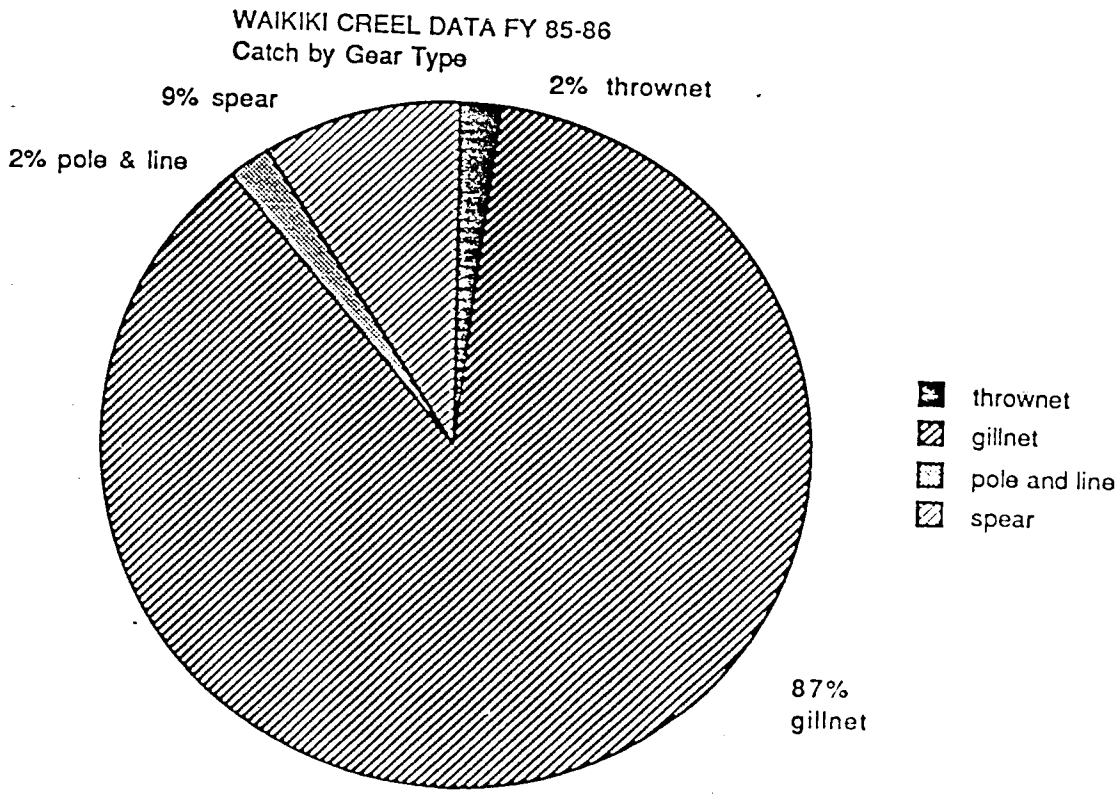
However, hourly catch rates (CPUE) by geartype showed no clear annual trends (trends seen for one geartype are reversed for another from year to year). The relative unpredictability of gear-specific catch indices may be due in part to the small number of interviews conducted during the seasons when the FMA was open to all forms of fishing. The sample size was limited by the amount of time and personnel that could be dedicated to creel survey activity. Catch rates per fisher are highly variable, for a number of reasons, so that an accurate assessment of CPUE depends on having a fairly large and representative sample. By limiting their activities to weekends, holidays and afternoons, surveyors were primarily interviewing people who fish recreationally. While this included some experienced fishers, CPUE sampled by geartypes were quite low, indicating that many fishers were either unskilled, unlucky or unmotivated. Catch rates of commercial fishers should be considerably higher, but many of these people fish the area overnight, before sunrise and on weekdays, when surveyors were not present. This is only one source of sampling bias in the creel survey data.

An intensive effort was dedicated to creel surveys during the first opening of the FMA (FY 1981 and 1982). This being the first such survey conducted by DAR, survey methodology development was a learning experience. Student surveyors patrolled the shoreline and interviewed as many fishers as they could in a single pass through the FMA. Fishers found closest to shore were more easily reached and interviewed, resulting in an emphasis on thrownetters and shoreline pole fishers. A high level of cooperation was obtained from a number of experienced (older) thrownetters, and interviews were conducted with these fishers during almost every survey. This provided detailed information regarding thrownet catches; but without realizing it, surveyors obtained a biased sample of fishing activity.

During the second open to fishing season (FY 1985-1986), another creel survey effort was mounted. Two things happened during that season which biased the surveys in a different manner. Several of the older thrownetters disappeared, presumably due to advancing age; therefore, these people were no longer interviewed. Secondly, having recognized that they had missed many gillnet fishers in previous surveys, creel surveyors began to focus on gillnetters, waiting on shore as long as necessary to obtain an interview when netters returned from fishing. As a result, while 1982 surveys probably under-represented gillnet catches, 1986 surveys may have over-represented landings of this gear. This effect is seen in Figure 2, showing the makeup of the surveyed catch by geartype. This figure shows a significant difference in recorded catches by geartype, but it is unclear to what extent the data reflect actual changes in catch at the FMA. Thus, subsequent creel surveys implemented at other locations in Hawaii have been designed to register the proportion of fishing activity by geartype as well as gear-specific catch rates.

FIGURE 2


WAIKIKI CREEL DATA FY 81-82
Catch by Gear Type
26%
spear
34%
thrownet
30%
gillnet
10%
pole & line


WAIKIKI CREEL DATA FY 85-86
Catch by Gear Type
9% spear
2% thrownet
2% pole & line
87%
gillnet
thrownet
gillnet
pole and line
spear

Another problem encountered in comparing percentages of catch registered between years lies in the variable number of interviews conducted on a yearly basis. The small sample size during FY 1986 means the catch of any one fisher represents a larger proportion of the total than in other years. In fact, a close examination of the data shows that the majority of gillnet landings registered during the 1986 survey were due to one fisher with about 1000ft of gillnet, who caught over 3000 menpachi in a single overnight set. His catch represents about 50% of all fish registered during the 1986 surveys (6769 fish). Thus, the results seen in Figure 2 would have been completely different depending on whether or not the one fisher was interviewed.

Because of sampling biases, an accurate estimate of total fishing effort and landings cannot be developed from creel survey data collected at the Waikiki-Diamond Head FMA. To obtain a representative sample of landings in a given area, gear-specific CPUE (number or weight of fish per hour by geartype), as well as the average hourly number of each type of fishing gear in the area (participation rates) must be recorded. The lack of participation rate data for the Waikiki FMA creel surveys makes it impossible to obtain an accurate estimate of the total catch by geartype in any of the management periods.

While total (or gear-specific) landings cannot be estimated accurately from creel survey data collected at the Waikiki-Diamond Head FMA, the huge catch of a single gillnet illustrates the potential for this gear to harvest a much larger proportion of available fish than most other fishing methods. Differences in the estimated catch by geartype due to changes in sampling bias illustrate the fact that the amount of catch by the gillnet fishery can be regulated based on the number and size of gillnets allowed to fish, as well as control of the amount of fishing activity.

3) Continued Management and Monitoring

On May 27, 1988, Hawaii Administrative Rules Chapter 13-48 was modified and a new administrative rule (Chapter 13-36) was established to create the Waikiki MLCD. Chapter 13-36 reduced the size of the Waikiki-Diamond Head FMA by approximately one third and established the Waikiki MLCD by instituting a permanent ban on all fishing in nearshore waters between the Kapahulu Groin and the western wall of the Waikiki War Memorial Natatorium. Modifications to Chapter 13-48 reduced the four-year management cycle in the FMA (two years open, two closed) to a two-year cycle (one year open, one closed), with fishing allowed during even-numbered years and prohibited during odd-numbered years. Additional changes included a total ban on gillnetting and night spearfishing in the FMA. Table 3 summarizes historical changes in management regimes for the Waikiki-Diamond Head FMA/MLCD Complex from 1979-1993.

Dive surveys to monitor fish abundance and diversity in the FMA/MLCD Complex have continued since 1989, as part of the Main Hawaiian Islands Marine Resources Investigation (MHI-MRI). Results are being summarized by Dr. Richard Brock. Dr. Brock's final report will be completed in December, 1992, and will be attached separately. Cycles of increased fish abundance in the FMA during years when fishing is prohibited have continued, with notable exceptions. Peak levels of abundance have been lower, presumably because of the reduced size of the FMA, shorter "fishing/no fishing" cycles and changes in gear allowances during "open" years. As shown earlier

(Figure 1), fish became most abundant during the second closed year. Therefore, abundance would be expected to be lower under the shorter management cycle.

TABLE 3: MANAGEMENT REGIMES IN THE WAIKIKI-DIAMOND HEAD FMA/MLCD COMPLEX 1979-1993

MAJOR MANAGEMENT REGIME	YEAR	SPECIAL PROVISIONS	
CLOSED TO FISHING	FY 1979	FMA I: Kapahulu Groin to Diamond Head Light-house. FMA encompassed two miles of shoreline, to 500 yards of shore.	
	FY 1980		
OPEN TO FISHING	FY 1981	FMA I: Open to pole & line/hand harvesting only.	
	FY 1982	FMA I: All fishing methods allowed.	
CLOSED TO FISHING	FY 1983	FMA I: No fishing of any kind.	
	FY 1984		
OPEN TO FISHING	FY 1985	FMA I: Open to pole & line/hand harvesting only.	
	FY 1986	FMA I: All fishing methods allowed.	
CLOSED TO FISHING	FY 1987	FMA I: No fishing of any kind.	
	FY 1988		
FMA: CLOSED TO FISHING EVERY OTHER YEAR MLCD: CLOSED TO FISHING PERMANENTLY	May-Dec. 1988[3]	FMA II = ⅔ size of FMA I	MLCD = remaining ⅓ FMA I
		Open: Pole & line, thrownet, handnet and daytime spearfishing only.	No fishing of any kind.
	1989	No fishing of any kind	
	1990	Open (as above 5-12/88)	
	1991	No fishing of any kind	
	1992	Open (as above)	
	1993	No fishing of any kind	

Resource recovery in the Waikiki MLCD is not a cut-and-dried matter either. Factors besides fishing that affect fish resources have also changed during recent years, so that changes cannot be considered as due solely to the effects of fishery management. Changes in water quality, tourism and traffic may also be a concern, with increasing urbanization and use of the area by swimmers and jetskiers. Commercial tour operations conducting fish feeding may also cause localized changes in fish abundance and diversity, as aggressively feeding species become more abundant. More sensitive indices of diversity, which take into account relative abundance (rather than just number of species) are now being considered to assess changes in fish communities in the Waikiki-Diamond Head FMA/MLCD Complex.

[3] The FMA rotated on a fiscal year basis (July 1 to June 30) from FY 1979 until the end of FY 1988. In May, 1988, rules governing the FMA were changed to utilize a calendar year cycle (which is easier for the public to keep track of). The FMA was open to fishing from May 27 through December, 1988; then began a one-year closed period in January, 1989.

b. Summary 1985-1992 Findings: Hilo Harbor FMA

The following section summarizes information obtained through creel surveys in an area restricted to gillnetting inside Hilo Harbor, on the Island of Hawaii. The Hilo Harbor FMA was developed by consensus among Hilo fishers. As a result, although gillnetting is prohibited inside the Hilo breakwall, gillnet fishers have an accessible area nearby (outside the breakwall) where they can fish. This compromise seems to have satisfied both gillnetters and other fishers in the area. There is a general agreement not to implement further changes unless absolutely necessary. Meanwhile, both hourly catch rates and the size of fish caught in the Hilo area have improved since management measures were developed.

Fishing surveys at Hilo began in 1985, in response to public concern regarding overfishing. Prior to 1985, there had been no studies of recreational landings in the area. Since HRS §189-3 only require that commercial landings be reported, the Hilo creel survey was designed to improve estimates of total landings in Hilo Bay by acquiring additional data on catch and effort by all shoreline fishers.

The first shoreline creel census was conducted by DAR personnel from September, 1985, through December, 1986, prior to the amendment of the Hilo Harbor FMA (Pre-Amendment Survey). On June 1, 1987, following a petition by Hilo fishermen, regulations governing the Hilo Harbor FMA (Hawaii Administrative Rules, Chapter 47 of Title 13, based on Regulation 35 of the Division of Fish and Game) were amended to prohibit the use of gillnets within the Hilo breakwall. Prior to the amendment, gillnetting was prohibited only in the Wailuku and Wailoa Rivers, and in a small portion of Hilo Harbor known as Radio Bay.

A second series of creel surveys began in 1987, after the FMA amendment. These surveys were conducted for DAR by students of the University of Hawaii at Hilo Marine Option Program from September, 1987 through June, 1988 (Post-Amendment I Survey). A third (Post-Amendment II) survey began in July, 1989, and continued through June, 1990. On July 1, 1990, the creel survey was redesigned and field methods revised to provide a more complete estimate of total shoreline fishery landings (Post-Amendment III Survey). Data from these three surveys are summarized in a report emphasizing the changes in hourly catch rates, species, and size of fishes and invertebrates landed before and after the closure of Hilo Harbor to gillnetting (Kahiapo and Smith, 1992). Portions of this report are summarized briefly here. Since methodology changed significantly in the Post-FMA III Survey, which is still in progress, only the previous three surveys will be discussed.

Data from 1985-1990 allow a comparison of changes in CPUE by area and geartype, and of size structure of landings of key species. Because shoreline creel surveys began well before the present Hilo Harbor FMA designation and have continued for several years since the amendment was adopted, the results obtained provide an index of how landings and fishing activity in the Hilo area have been influenced by management measures. Creel surveys have also provided a means of establishing closer contact with local fishers to exchange ideas, which contributed to the consensus building process that lead to establishment of the present FMA.

Creel surveys cover Hilo Harbor FMA and the adjoining Keaukaha Shoreline, as well as Waiākea Pond Public Fishing Area (PFA). Effects of management in the FMA

may well be seen at all three locations, since many species protected in Hilo Harbor migrate freely between the three areas; however, only data from Hilo Harbor will be discussed. Shoreline surveys in Hilo Harbor represent overall trends inside the breakwall fairly well, since the majority of fishing activity in the area takes place from shore. Small boats play a significant role in the fishery outside the breakwall at Keaukaha, and differences in management and habitats in all three areas make it advisable to evaluate them separately.

Hilo Harbor is somewhat protected from the sea and receives freshwater from several streams and rivers. It supports a variety of estuarine and marine species, and important seasonal fisheries for fishes such as akule, 'ama'ama and uluas (or papio). Shoreline fishers in Hilo Harbor also target on white crabs the year round. The principal gears used in the Harbor are pole and line (with or without a reel), scoop net, and thrownet. Recreational fishing is important at Hilo, which has an extensive and accessible shoreline. Areas dominated by recreational fishers include Reed's Bay, the Hilo breakwall and much of the shoreline inside Hilo Harbor.

Table 4 outlines the survey dates, locations covered, number of interviews, CPUE (per fisher), and place of residence of fishers interviewed. Anyone from outside Hilo was grouped into the "elsewhere" category. The largest group of fishers by far were Hilo residents, followed by people from other places on the Big Island. Surveyors contacted 4285 fishers over the five-year period, in a total of 2317 interviews. More interviews were conducted during the last year, when a staff member was allocated to the project fulltime. Creel surveys were at first conducted on an experimental basis. As the value of the data collected became evident an increasing emphasis was placed on this activity, despite the demands on available personnel. The Pre-Amendment and Post-Amendment I Surveys were conducted only during daylight hours (weekdays and weekends). The Post-Amendment II Survey was the first to encompass early mornings, nights and holidays.

TABLE 4: SUMMARY OF 1985-1990 CREEL SURVEYS AT HILO

SURVEY: Dates	No. Interviews	No. Fishers	No. Fish Caught	OVERALL CPUE (Fish/Fisher)	RESIDENCE	
					% HILO	% ELSEWHERE
Pre-Amendment: Sept.1985-Dec.1986	139	223	622	2.78	92.6	7.4
Post-Amendment I: Sept.1987-June 1988	241	412	428	1.78	88.4	11.6
Post-Amendment II: July 1989-June 1990	1937	3650	13772	7.11	79.3	20.7
TOTALS:	2317	4285	14822			

Table 4 shows the dramatic increase in catch rates since gillnetting within Hilo Harbor was prohibited. This trend is not clear in Post-Amendment I data, due in part to the small number of Post-Amendment I (and Pre-Amendment) interviews, high variability of catches, and time lag between implementation of management measures and their impact on the population (as seen at Waikiki). Length-frequency data show a similar time lag in some cases (Figures 3-6). Although the length of fish caught in the FMA has increased steadily throughout the three surveys, the trend is most apparent in data from the Post-Amendment II period. Figures 3-6 illustrate changes in length composition of the catch of four of the more abundant species.

FIGURE 3

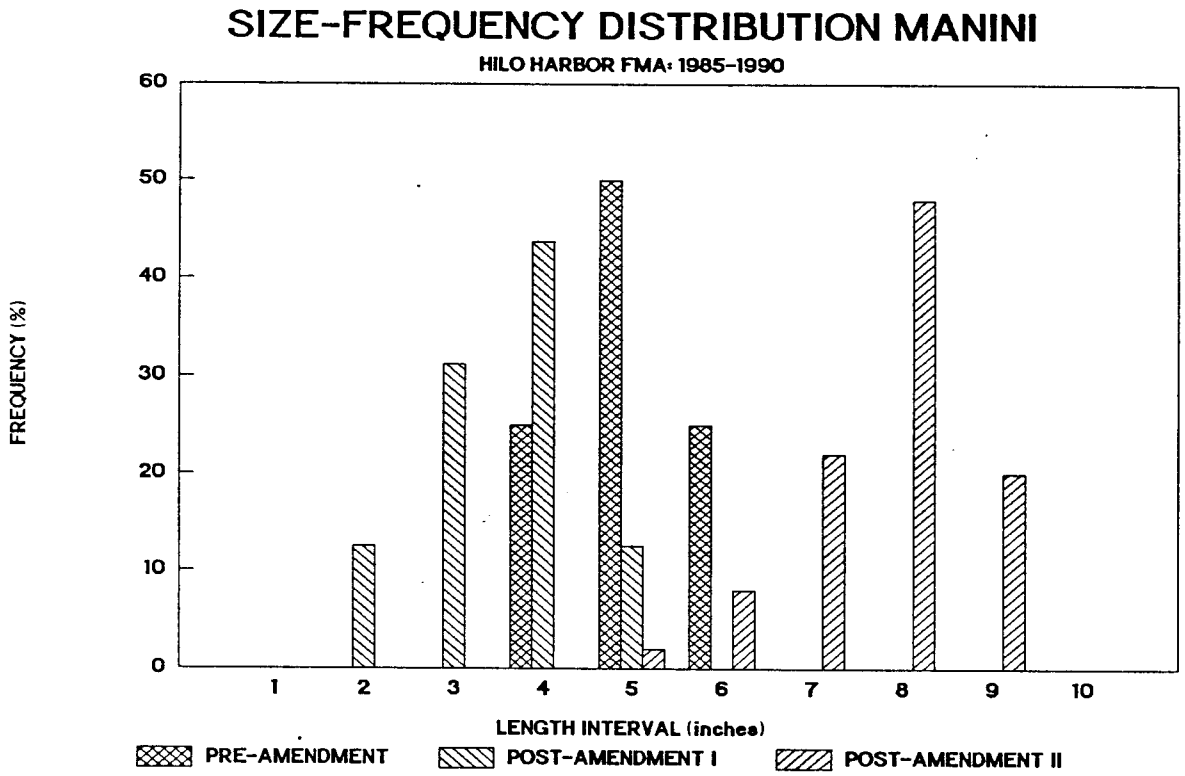
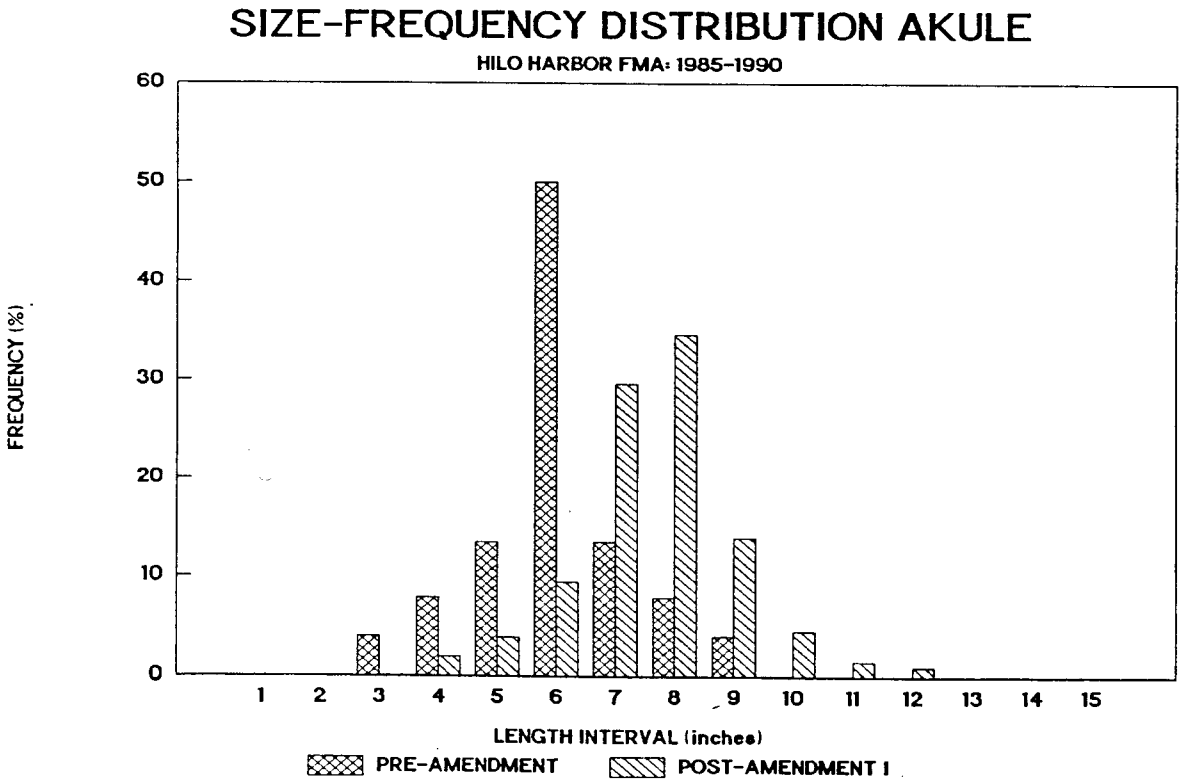


FIGURE 4



c. Summary 1990-92 Findings: Kaneohe Bay

A creel survey is also being conducted at Kaneohe Bay, on Oahu, through the MHI-MRI project. Researcher Alan Everson's 1992 report summarizes data collected from 1990-1992. This extensive report will not be discussed in detail here; only those aspects pertinent to gillnetting in the Bay are mentioned. Gillnetting issues in Kaneohe Bay are also described in the following section on information obtained through public meetings.

Having learned from previous creel surveys, the one at Kaneohe Bay was designed to estimate total landings (from small boats and from shore), as well as gear-specific catch rates. Surveyors interview fishers to obtain information on hourly and total catch. They also record hourly participation rates throughout the day, either using a spotting scope or driving along the coast and counting fishers on the Bay by geartype. Since surveys take place from 6:00 a.m. to dusk, the data are more representative of daytime fishing. However, night fishers are often interviewed when they return early in the morning, so some night catches are recorded.

Table 6 summarizes estimated CPUE and total annual landings by geartype for Kaneohe Bay. CPUE is estimated in pounds per hour for spear, pole and line, trolling and crabnetting; and in pounds per day for gillnets, surroundnets and traps. To make these values comparable, a six-hour fishing day was assumed for the first four methods, so daily catch rates by geartype could be estimated (Figure 7). Figure 7 includes catches by fishers using dive-hand methods (and a rock hammer) to harvest featherduster worms for the aquarium trade. Their catch rates are estimated based on an average individual weight of 30 grams per worm. Figure 8 shows the proportion (% weight) of total landings by geartype. Gillnet catches make up a little over a third of the total catch estimated for Kaneohe Bay.

TABLE 6: LANDINGS AND CPUE BY GEARTYPE KANEOHE BAY

METHOD	CPUE (units as indicated)		ESTIMATED ANNUAL CATCH		
			Lbs.	% of Total	RSE(%)[5]
Spear	1.83 (lbs/hr)	10.98 (lbs/dy)	29,112	25.30	22.9
Pole & Line	0.69 (lbs/hr)	4.14 (" / ")	21,360	18.56	15.4
Troll	0.78 (lbs/hr)	4.68 (" / ")	2,828	2.46	23.1
Crabnet	1.92 (lbs/hr)	11.52 (" / ")	5,631	4.89	(not available)
Gillnet	34.77 (lbs/dy)	34.77 (" / ")	71,241	35.06	53.2
Surroundnet	437.47 (lbs/dy)	437.47 (" / ")	27,524	11.84	87.8
Trap	9.00 (lbs/dy)	9.00 (" / ")	2,167	1.88	21.6
Hand/hammer (aquarium)	44.18 (no/hr)	265.08 (#/day)	—	(not included)	—
		TOTALS ——>	159,863		

[5] The Relative Standard Error (RSE) estimates the percentage possible error in the annual lbs estimate, based on observed variation in catches. RSE is higher for methods with more variable catch rates, such as gillnet and surroundnet fishing.

FIGURE 7

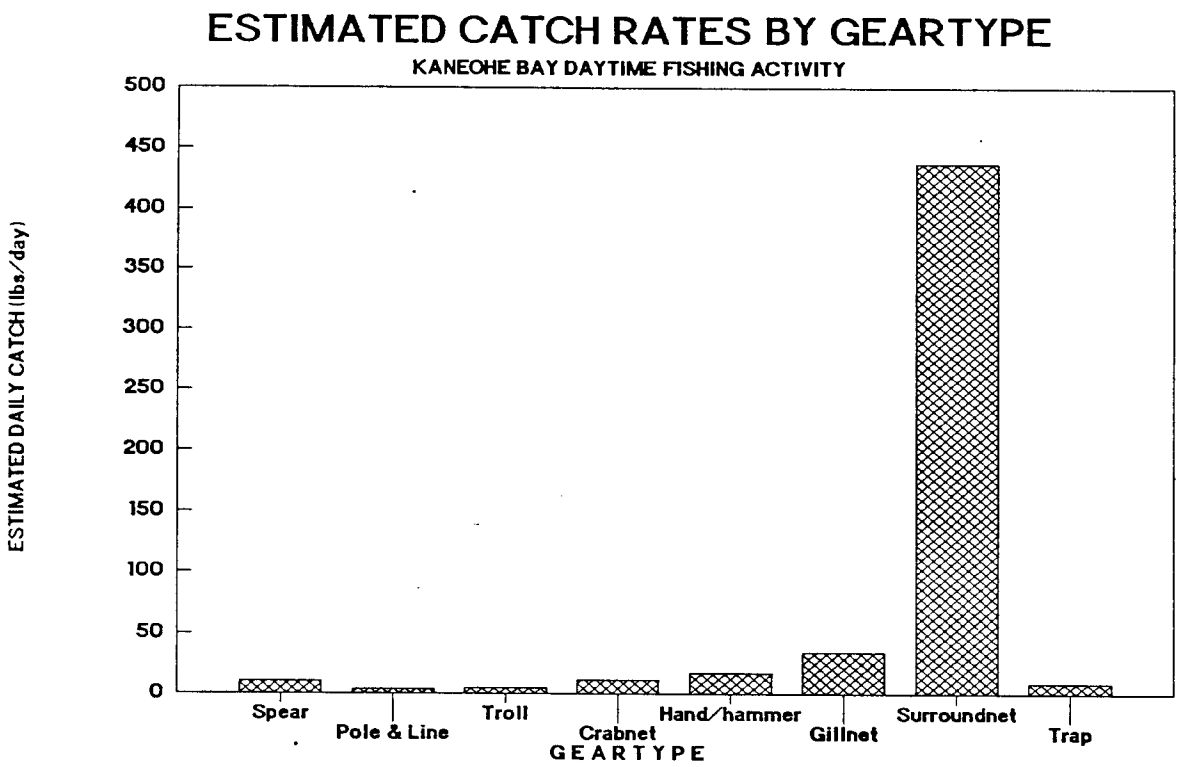
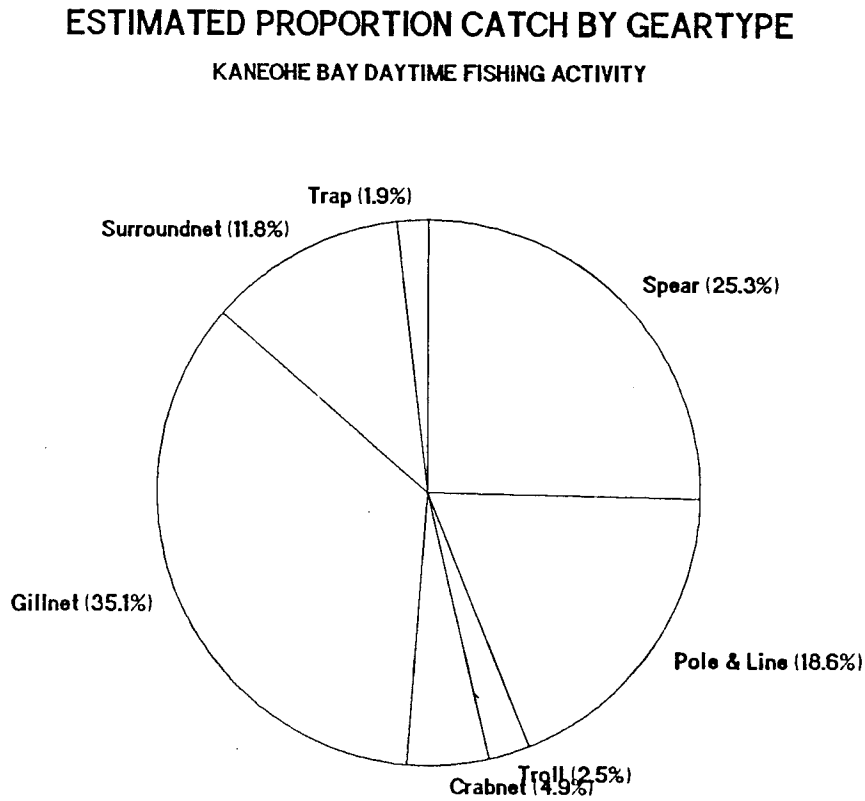


FIGURE 8



2) Review of Information from Public Meetings

a. 1991 Findings and Recommendations of the Kaneohe Bay Task Force Regarding Gillnetting

Act 208, of the Fifteenth Legislature's 1990 Regular Session, established the Kaneohe Bay Task Force to develop a comprehensive plan for water based activities in Kaneohe Bay. The Task Force was given a year to complete this task, during which it undertook a qualitative evaluation of the impacts of a variety of activities affecting the Bay users and environment. Broad based public meetings, and smaller committee and subcommittee sessions attempted to identify factors responsible for major impacts on the Bay and develop solutions to these problems. Issues relating to "water use" were assigned to a committee to be discussed, evaluated and resolved to the extent possible in the time provided. Each committee was asked to: 1) define the problem, 2) determine how the Bay was being impacted, 3) develop a full range of regulatory options for resolving the problem, 4) mitigate differences, derive concessions and formulate compromises in an open forum of discussion to produce a set of proposed recommendations.

The Fishing Subcommittee (of the Water Uses Committee) was made up of fishers, researchers and others interested in fisheries and related issues. This Subcommittee was asked to address the issue of declining fish catches in Kaneohe Bay. Specifically, there was concern about the impacts of two (or three) types of fisheries on declining fish populations: 1) gillnetting and 2) netting and spearfishing with SCUBA. Because it was identified as a problem, there was extensive discussion of the impacts of gillnet fishing over the one-year period that the Task Force was in operation.

The causes of the decline in resource abundance in Kaneohe Bay were unknown. Some fishers denied there had been a decline. Kaneohe Bay did appear to be entering a period of improvement in longterm cycles of abundance. Most of those present felt that resource abundance had indeed declined from past years. Potential causes of declining catches that were identified included overfishing; changes in fishing methods, species preferences, and gears; changes in spawning and migration patterns; environmental factors; pollution; disturbance due to increased boating activity (including commercial and non-commercial recreation), and; illegal or destructive fishing activities (such as the use of chlorine). Information obtained indicated that several important environmental concerns need to be addressed, in addition to overfishing. These concerns should be kept in mind, but are not the subject of this report, which addresses gillnet fishing.

There was a problem in obtaining accurate assessments of the amounts and trends in Bay fisheries, since no reliable estimates of resource abundance exist for this region. Kaneohe Bay has been extensively studied for corals and reef fishes not targeted by the fishery, but not for food fishes. Commercial landings data from the DAR were reviewed, but the data provide only a partial index of resource abundance, since only commercial fishers are required to report and not all of them report completely or accurately. Results of the creel survey were not available at that time, and would not have covered a sufficient period of time, since the survey began in 1990.

The Fishing Subcommittee selected about twenty of the most important species in Kaneohe Bay to evaluate trends in abundance and catch by geartype. The proportion of catch by fishing gear varies with species, but by combining the results for the important species caught, overall trends became apparent. Gillnetting was responsible for 2-10 times more of reported commercial landings than other fishing gears (Figure 9), during the years from 1960 to 1983. Surroundnetting also accounted for occasional large catches, but these were much more variable (i.e. fishers would have a large catch once in a while, with long periods of low or zero catches). After 1983, gillnet landings declined dramatically, as did catches by most other gears. Fishers with other types of nets held their own or increased their catches slightly from 1984-1988, with the result that reported landings by these gears surpassed landings by gillnetters in Kaneohe Bay for that period.

Overall trends in reported commercial landings from 1948-1988 are seen more clearly in Figure 10. Total commercial landings (of the twenty species selected) decreased from 1950 to 1960, increased from 1960 to about 1970, fluctuated wildly during the 1970's (as is characteristic of over-harvested fisheries), and began a steady and continuous decline about 1978. The most recent decline (since 1978), followed a period of expanded use of gillnets and deteriorating water quality in Kaneohe Bay. Overall trends are shown in the figure. Although data regarding fishing efforts are not as detailed as would be desirable, both reported catch rates and number of trips indicate that an increase in landings during the 1960's may have been due to a change in fishing methods from handlines to gillnets. The decline in landings since 1978 appears to be attributable to both reduced catch rates and a smaller number of fishing trips. The decline in catch rates indicates decreasing fish abundance in the Bay, while the reduction in trips may have been a response to less successful fishing.

Although gillnet fishing was discussed extensively by the Task Force, the prevailing opinion was that no single gear type was solely responsible for the decline in resource abundance. Accordingly, fishers were only in favor of regulations which impacted all geartypes equally, while gillnetters resented being singled out for restrictions. There was also a feeling that existing rules should be better enforced before new regulations were implemented.

While the Task Force as a whole did not agree on recommendations to regulate gillnet fishing in the Bay, deferring this issue for later consideration by a panel of fishers, the smaller committees struggled with the issues, and were able to develop and agree on a series of recommendations. Both committee-level and subcommittee-level discussions included many gillnet fishers. Although the Water Uses Committee and Fishing Subcommittee recognized that the decline in resource abundance in the Bay was not all due to the effects of gillnetting, a range of measures were recommended to alleviate pressure on the resource by this fishery.

The recommendations proposed by the Fishing Subcommittee, and ratified by the Water Uses Committee are listed in Table 7. For the purpose of its recommendations, the Subcommittee defined Kaneohe Bay as the area between Kualoa Point and Pyramid Rock, within and including the barrier reef to a depth of 50 feet. They further stated that all net restrictions proposed (a range of options were provided) would be per boat, as opposed to per person or any other.

FIGURE 9

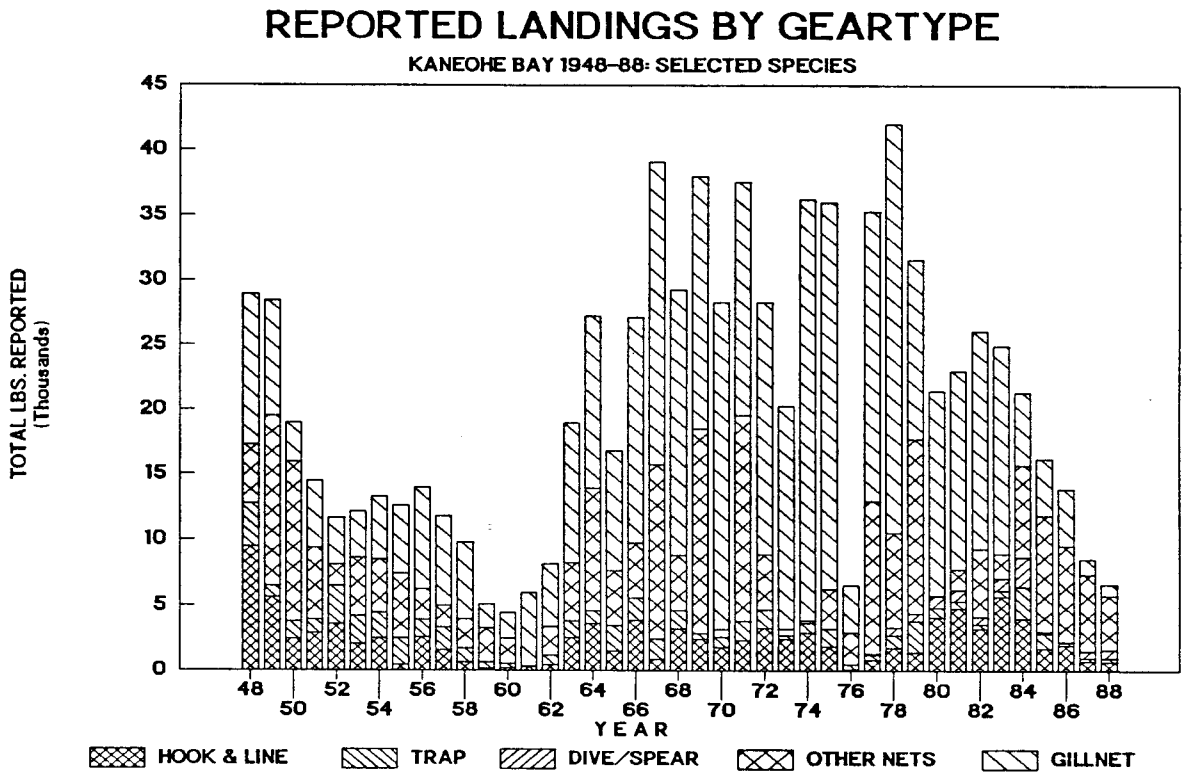


FIGURE 10

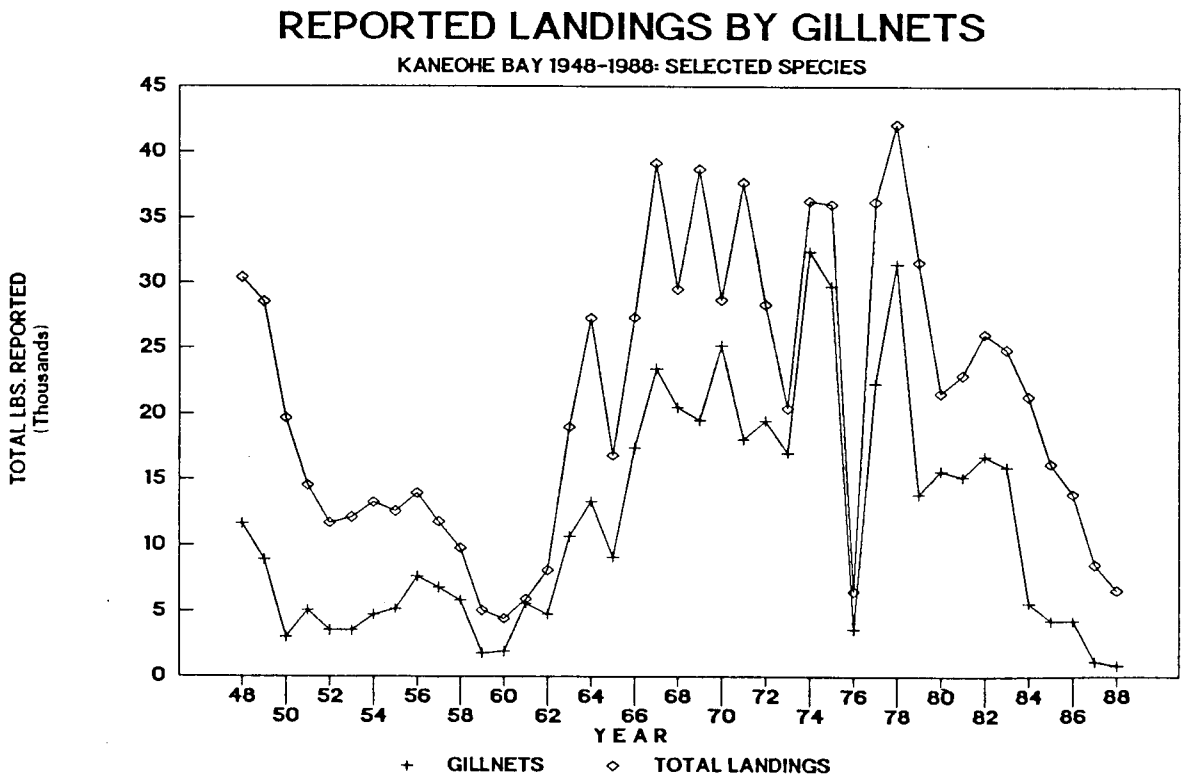


TABLE 7: MEASURES PROPOSED BY THE FISHING SUBCOMMITTEE TO IMPROVE FISH CATCHES AND REGULATE GILLNET FISHING[6]

1. Provide stiffer penalties that would more effectively serve as a deterrent to illegal activity and enforce strictly.

2. Improve enforcement of existing regulations and public awareness of them through an educational campaign (including outreach to the public and the judiciary).

3. Study the decline in abundance of Bay resources, overfishing, and what is to be done about it if it is a problem. Conduct research to determine how to best protect resources, with input and cooperation of fishers. Studies designed to:
   a. Evaluate impacts of gillnetting and other net fishing on abundance of living marine resources.
   b. Determine the allowable mesh size for gillnets, based on a study of mesh size selectivity and information regarding minimum size of reproduction for the Bay's fishes.
   c. Evaluate the allowable number and length of gillnets in the Bay.
   d. Evaluate the need for more bag limits.
   e. Determine when and where to place closed seasons for species not covered by existing regulations.
   f. Establish legal size limits, based on size at sexual maturity.
   g. Evaluate the need to protect inshore nursery and reproductive areas.
   h. Evaluate the impact of nehu netting on the Bay ecosystem.
   i. Evaluate means of stock enhancement for depleted species.
4. Ban jet ski activity because of its interference with fishing.
5. Limit tour operations for the same reason given in #4 (limitations determined by consensus).
6. Intensify monitoring of resource abundance, fisheries, nutrients, toxics, and other environmental conditions.
7. Form a Fishing Panel, with members representing all fishing methods, to detect and resolve fishery management issues.
8. Develop a statewide recreational fishing permit, making it possible to estimate the total number of recreational fishers.

9. The following options were developed to deal with the issue of gillnetting. A full range of alternatives were developed for consideration, one of which was to have been selected by the Task Force and implemented, subject to revision in accordance with the findings of studies in #3.

Maximum Limitation:

1. Ban on all gillnetting from sunset to sunrise
   a. Gillnet defined as any net which gills all or part of its catch (including surround, circle, lay, cross, paipai and hukilau nets). Thrownets not included.
   b. Consider a reasonable phase out period.
2. Daytime net lengths restricted to a maximum of 250 feet.

Moderate Limitation:

1. Restriction on overnight ("moi moi") gillnetting as defined below:
   a. No monofilament gillnet shall be set within Kaneohe Bay between sunset and sunrise for a period in excess of six consecutive hours.
   b. Night net lengths restricted to a maximum number length determined in mediated discussions.

2. Persons engaged in any type of netting (day or night) within Kaneohe Bay using nets in excess of 500ft per boat must have a valid commercial fishing license. These persons would be required to report total catch landed in Kaneohe Bay and be subject to rules and penalties for non-reporting set forth in Hawaii Revised Statutes.

No Action

(To be fair, the range of options considered included not doing anything.)

[6] Measures above the double line were generally agreed on. Those below the line were agreed on only after considerable discussion.

The Water Uses Committee and Fishing Subcommittee of the Kaneohe Bay Task Force both made significant progress toward developing a solution to Kaneohe's gillnetting issues. While members started out at odds, through discussion and compromise divergent points of view came closer together. Both gillnetters and non-gillnetters entered the discussion with a concern for the Bay's resources, and contributed to the successful resolution of the issues. The committee and subcommittee groups reached consensus regarding an allowable net length for recreational versus commercial fishing. The most specific guidelines developed are set forth in the lower portion of the table. However, the subject of gillnetting was overwhelmed by the large number of other critical decisions to be made by the Task Force as a whole. Moreover, the Task Force felt that the final decision should involve input from a more representative and larger group of fishers than had been able to attend their lengthy late-night meetings.

Several things are worth noting about the types of recommendations developed with the aid of fishers. There was little difficulty in agreeing on an amount of time the nets could be left unattended. Everyone agreed that the legal limit of 12 hours was far too long. Fishers didn't want to give up the option of retiring to shelter for some period of time, but they agreed with a requirement that the net be checked every few hours. Fishers said if they don't check the net frequently, their fish will spoil or be eaten by predators. The length of time favored ranged from 2-4 hours.

Discussion on an allowable net length was more heated and it was harder to reach an agreement. Recreational fishers need less net to catch fish for home consumption than do commercial fishers, so concessions were made to accommodate this difference. Although no one wants to be forced to do paperwork, it was agreed that anyone fishing with more than 500ft of net would be required to obtain a permit and report their catch, since it was unlikely they would not sell any excess fish caught (commercial fishers using nets shorter than 500ft would still be required to report).

Mesh sizes were another debatable question, and it was agreed that careful study of the problem was necessary in order to make the right decision. No difference of opinion was found to be insurmountable during these meetings, and a better understanding was developed between all parties as the discussion continued.

b. Other Public Meetings

The principal lesson learned from other public meetings is that the most vocal group is always the one facing restrictions. When the issues are not thoroughly discussed with the public beforehand, meetings can become heated. For this reason, it is important to bring the public into the process at an early stage. Controversy is not always counterproductive, and if a forum can be provided in which to air differences of opinion and develop an informed consensus, most issues can be resolved to the satisfaction of the participants. This may initially involve the use of resourceful means of preventing intimidation of people with unpopular viewpoints; getting people to speak up; maintaining order and respect among participants; and letting people know their opinions are being heard and understood. By informing the public and getting their input, gillnetting issues can be resolved in this type of forum, once the information has been presented in its entirety.

3) Commercial Catch Statistics

A moment should be taken to examine the State's commercial landings data, reported to the DAR. However, as mentioned previously this information cannot be used for a complete evaluation of the fishery because of its limited scope. Gillnet fishing is a popular activity among recreational fishers, who are not required to report their catch. Reporting is required only of commercial fishers, defined as anyone who sells a fish or more annually. In practice, not all such fishers report and many report only a portion of their landings. This is one reason that a complete and detailed assessment of the present status of the fishery will take the time necessary to obtain more information through creel surveys.

Notwithstanding these problems, the State's commercial landings database is the only consistent, detailed and longterm information available for Hawaii's fisheries. Although total landings are underestimated in the data, overall trends have been substantiated through interviews with local fishers.

Table 8 summarizes the proportions of the most popular fishing gears employed by inshore commercial fishers around the Main Hawaiian Islands. This information is provided by island platform groups, since each region has its own unique characteristics. Commercial fishers report their catch by area and geartype. However, they are not always as specific about geartype as would be desirable; therefore, related fishing gears are grouped into a single category in the database. The most abundant inshore gear around all islands is the bottom handline. Trolling (for large pelagics) is second in importance for the Kauai Complex (Kauai, Ka'ula Rock and Ni'ihau) and the Big Island. This rank is taken by diving, spearing and other reef methods around Oahu and the Maui Complex (Molokai, Lanai, Maui and Kaho'olawe). Gillnetting and related methods ranked third around all islands except Hawaii, where surroundnet fishing (for opelu) is more important. Thrownetting is more prevalent in inshore areas around the Maui Complex than in other areas. A large amount of trapping takes place around Oahu.

There is not necessarily a direct relationship between gear frequencies and the proportion of landings by geartype. In fact, the least abundant gears often show the highest catch rates. Table 9 illustrates this, showing mean CPUE (lbs per trip) and number of trips by geartype (hours fishing are not reported). Gears such as longlines, gillnets and surroundnets catch a larger proportion of fish than other geartypes. With regard to net fishing, gillnets are second to bag and surround nets, both in CPUE and total catch. However, gillnets are more widely used by recreational fishers. Thus, the total catch of gillnets is probably considerably more than the amount reported commercially. Fish caught by surround methods can be kept alive for long periods of time and released or harvested selectively. Surround and bag net catches are sporadic, but can exceed those of any other type of fishing gear, particularly when used in conjunction with spotter planes. Gillnets are more consistent in the amount of their catch and because there are a larger number of fishers, total landings should be equal to (if not more than) surroundnet landings.

TABLE 8: ANNUAL MEAN PROPORTION OF INSHORE COMMERCIAL FISHING TRIPS BY GEARTYPE AND GEOGRAPHIC REGION 1980-1990

	Fishing Gear/Method(s)	Annual (%) Trips[7] Within 3 miles
Kauai Complex	Aku Boat/Longline/Flagline/DPH[8]	2.5
	Bottom Handline	42.4
	Kaka Line/Set Line, Ikashibi, Palu'ahi	0.7
	Trolling	19.4
	Rod and Reel (light tackle)	0.1
	Trap	1.9
	Diving (Knife, Spear, Handpicked)	11.8
	Seine/Gillnet/Hukilau Net	12.5
	Akule/Opelu/Surround/Purse Nets	2.1
	Thrownet	1.7
	Lobster/Crab Nets (include loops)	1.9
	Other (and unspecified)	3.1
Oahu	Aku Boat/Longline/Flagline/DPH	1.0
	Bottom Handline	46.2
	Kaka Line/Set Line, Ikashibi, Palu'ahi	0.3
	Trolling	4.5
	Rod and Reel (light tackle)	0.2
	Trap	10.7
	Diving (Knife, Spear, Handpicked)	15.3
	Seine/Gillnet/Hukilau Net	12.1
	Akule/Opelu/Surround/Purse Nets	2.7
	Thrownet	0.9
	Lobster/Crab Nets (include loops)	1.8
	Bait Net	<0.1
	Other (and unspecified)	4.1
Maui Complex (Maui, Lanai, Molokai & Kahoolawe)	Aku Boat/Longline/Flagline/DPH	0.8
	Bottom Handline	33.3
	Kaka Line/Set Line, Ikashibi, Palu'ahi	<0.1
	Trolling	14.4
	Rod and Reel (light tackle)	0.2
	Trap	3.0
	Diving (Knife, Spear, Handpicked)	22.1
	Seine/Gillnet/Hukilau Net	14.9
	Akule/Opelu/Surround/Purse Nets	3.5
	Thrownet	4.1
	Lobster/Crab Nets (include loops)	2.0
	Other (and unspecified)	1.9
Hawaii	Aku Boat/Longline/Flagline/DPH	3.0
	Bottom Handline	56.1
	Kaka Line/Set Line, Palu'ahi, Ikashibi	1.3
	Trolling	14.3
	Rod and Reel (light tackle)	0.5
	Trap	0.8
	Diving (Knife, Spear, Handpicked)	8.8
	Seine/Gillnet/Hukilau Net	2.7
	Akule/Opelu/Surround/Purse Nets	8.8
	Thrownet	1.5
	Lobster/Crab Nets (include loops)	0.4
	Other (and unspecified)	1.9

[7] Mean proportion of trips reporting this geartype (1980-1990).

[8] DPH = Drifting Pelagic Handline

TABLE 9: MEAN INSHORE CATCH PER TRIP 1980-1990 BY GEARTYPE FOR PRINCIPAL FISHING GEARS (WITHIN 3 MILES OF SHORE)

GEARTYPE	ANNUAL MEAN (1980-1990)		
	Trips	Total Landings (lbs)	Catch Rate (CPUE) (lbs/trip)
Aku Boat (pole and line)	36.3	10245.6	282.2
Longline/Flagline	30.3	8648.2	285.4
Drifting Pelagic Handline	641.8	33581.3	52.3
Bottom Handline	8976.8	426581.4	47.5
Kaka Line/Set Line, Ikashibi, Palu'ahi	87.2	15992.3	183.4
Trolling	4450.8	108711.0	24.4
Rod and Reel (light tackle)	114.5	1141.4	10.0
Trap	371.1	57078.4	153.8
Diving (Knife, Spear, Handpicked)	1154.4	91660.6	79.4
Seine/Gillnet/Hukilau Net	1157.8	227443.4	196.4
Akule/Opelu/Surround/Purse Nets	641.0	347869.4	542.7
Thrownet	681.5	7843.4	11.5
Bait Net	2.0	11.4	5.7
Lobster/Crab Nets (include loops)	171.4	9327.4	54.4

4) Review of Testimony and Proposed Regulations in Recent Years

A number of other points for consideration in the regulation of gillnetting are illustrated by the content, debate and fate of legislation proposed for this fishery over the past three years. During the Fifteenth Legislature's 1990 Regular Session, House Bill 3442 was introduced, which would have made it "unlawful to possess or use any gillnet in any embayment estuary and fishing conservation area in the State". The concern in embayments and estuaries was that these areas serve as a nursery ground to many species, making the protection of these areas paramount to the continued well being of adult populations. Discussion revolved around the definition of "embayment estuary" and "fishing conservation area", with the recommendation from DLNR that it be provided authority to define and delineate specific boundaries of embayment estuaries within FMAs pursuant to the Administrative Rules process. The DLNR further recommended the term "fishing conservation area" be replaced with our already defined "Marine Life Conservation District". H.B.3442 was revised accordingly as H.D.1, and later died in committee.

The issue resurfaced, in the Sixteenth Legislature's 1991 Regular Session. The initial wording of H.B.38 was identical to the 1990 H.B. 3442, prior to it's revision to H.B.3442 (H.D.1). DLNR again clarified the terminology and suggested revisions to H.B.38 in ways similar to H.B.3442 (H.D.1). DLNR's recommendations included provisions to exclude two types of net fishing (using paipai and hukilau nets) from the restriction, since these methods involved constant tending of the catch and thereby would cause reduced accidental mortality of untargeted species, which might die before they could be released. This introduced to the discussion the importance of the amount of time a fish is ensnared in a net as a factor in fishing mortality due to gillnets.

More of the underlying complexity of the gillnet issue emerged throughout the ensuing discussion over the exemption of paipai and hukilau net fishing. Despite DLNR's recommendations, these methods were not exempted in the preliminary version of H.B.38. DLNR again testified that paipai and hukilau netting should be excluded from the regulation, because these involved active setting, chasing and bagging of fish that are removed in a short period of time. The testimony described the suffocation of unwanted fish in gillnets left unattended for long periods of time. Our suggested wording of the bill stated that it would be "unlawful for any person to possess or use a gillnet in any embayment estuary or marine life conservation district in the State, except for hukilau net or paipai net which are fished less than two hours at a time" and left it up to the Department to "...adopt rules in accordance with chapter 91 to define and delineate the boundaries of embayment estuaries and marine life conservation districts if such boundaries (were) not already established by statute or rules." Thus, time and fishing method were recognized as important factors, as was the need for careful review to determine the specific fishing areas where gillnetting would be disallowed.

The Department later testified that discussion of the bill with shore fishers pointed out the difficulty of distinguishing a paipai net from the prohibited gillnets for enforcement purposes, since the only difference would be the way the nets were used. Therefore, DLNR concurred that hukilau netting be exempted from the regulation, but that paipai netting would be included. H.B.38, Senate Draft 1 (S.D.1) emerged stating simply that it would be "unlawful for any person to possess or use a gill net

in any embayment estuary or marine life conservation district as defined and delineated by the department by rules adopted in accordance with chapter 91." This bill again died in committee.

H.B.38 (S.D.1) resurfaced in the Sixteenth Legislature's 1992 Regular Session, with a few changes. The discussion during 1990 and 1991 had left it clear that one of the principal objections to gillnet fishing was that nets were being left unattended for long periods of time, causing excessive mortality of fishes and other organisms entrapped in the nets. Endangered species were another concern, specifically sea turtles which drown in nets left for long periods of time. Accordingly, the 1992 proposed H.B.38 (S.D.2) attempted to revise the statute regulating gillnetting to reduce the amount of time the nets could be left unattended, in addition to restricting fishing areas. However, the new draft differed from the 1991 H.B.38 (S.D.1) or any of its predecessors in that it also prohibited all net fishing out to five hundred yards of shore, or to beyond the edge of the reef, regardless of whether or not this fishing occurred in an embayment, estuary or marine life conservation district. The 1992 proposed H.B.38 (S.D.2) would have changed HRS §188-30.2 as follows (changes underlined):

"**Fishing with gill nets; prohibited.**

(a) It is unlawful for any person engaged in gill net fishing to leave the person's net unattended without removing the catch every two hours or to leave the net in the water for a period of more than twelve hours.

(b) It is unlawful for any person to possess or use a gill net in the water from the highwater mark onshore to five hundred yards offshore or to the edge of the fringing reef, including the channels between the reefs, whichever is farthest, except for akule fishing or as may be allowed by administrative rules."

DLNR's 1992 testimony regarding the proposed H.B.38 (S.D.2) restated the foregoing historical discussion, and concurred with the purposes and intent of the bill, although it recognized that there were many practical problems with the 500-yard requirement. DLNR identified the need to check the nets more frequently (every two hours) and remove fish that were not wanted so they might survive, and stated that nets should be moved after fishing for twelve hours in a single location to avoid overfishing.

The proposed H.B.38 (S.D.2) was opposed by those fishers who were aware of its existence, because of part (b) which prohibited inshore gillnetting. A number of net fishers testified against the bill. Most of these were akule netters, who said they were opposed to the blanket prohibition of inshore gillnetting in spite of the fact they themselves would be exempted from this regulation when using their surroundnets. The reason they gave was that the measure would essentially eliminate gillnetting, since most gillnetting occurred either within the reef or within 500 yards of shore. Their fear was that they would be the next fishing method prohibited in Hawaii. When the proposed H.B. (S.D.2) was heard by the Senate Committee on Agriculture and Environmental Protection, it was amended to omit all reference to prohibiting inshore gillnetting. The new H.B.38 (S.D.2) went on to increase the time a gillnet could be left in the water to eighteen hours, stating that fish should be removed every twelve hours. This bill died in committee for obvious reasons.

5) Information from Interviews with Gillnet Fishers

Information presented throughout this report was developed with the assistance of inshore gillnet and other net fishers. Most of the information provided by fishers has been incorporated into other sections, however a few additional points are worth noting. Fishers have pointed out a number of features of gillnet fishing which have not come out of other studies. These observations will be listed briefly, to illustrate the fact that a wealth of information could be obtained to better manage the fishery and assess its impacts, if the time could be taken to enlist the assistance of fishers.

A dialogue has begun between DAR and some of the leaders in the fishery. Fishers recognize the need for regulatory measures and would like to play a constructive role in the development of sound policy to ensure the survival of the resources well into the future. To this end, some of the key gillnetters would be willing to help contact other fishers, get them to discuss the options and develop a set of recommendations that would be supported by Hawaii's gillnet fishers. This should be done on a regional basis, since each area has unique features and needs. Solutions can be more easily developed in less populated areas on the neighbor islands. Furthermore, regulations developed on Oahu may not be suited to other islands. Fishers recommended a series of regional meetings on the five major islands (Oahu, Kauai, Maui, Molokai and Hawaii) to develop area-specific or seasonal closures in specific areas. A network of fishers could be easily mobilized to assist in reaching gillnetters and obtaining their input and cooperation. Such measures would be better received, once fishers became fully involved in their development.

Although funding was not provided to conduct an in-depth survey, informal surveys and interviews with fishers make it apparent that a large number of recreational fishers are involved in gillnet fishing on all islands. Data collected with the help of fishers on Oahu showed that people of a wide range of ages fish with gillnets for recreation and subsistence. The oldest fisher who contributed information had been involved in the fishery for more than 50 years. Having retired from commercial fishing, he continues to fish infrequently for food and enjoyment. Many recreational fishers use their nets only 3-6 times a year, but they would like to be allowed to participate in this activity from time to time. A common practice on Oahu is for 3-6 recreational fishers to get together once or twice a month and catch fish with gillnets (sometimes using the paipai method) for a family picnic, much like the old practice of hukilau netting. These types of activities, their frequency and impact need to be better understood. A principal fishing supply dealer on the island of Oahu stated that by far the largest number of nets are sold to recreational fishers, indicating that there are a large number of fishers whose catch is unregistered. An effort will need to be made to include the entire fishery in management considerations.

Another point made is that mesh size has a double edged effect. A given mesh size not only allows smaller fish to pass through, but will also exclude larger fish. One of the concerns of fishers about using a mesh that is too large is that there will be an increased tendency to catch larger unwanted organisms, including sea turtles. This was the case in California, where the six-inch mesh used for halibut had to be excluded from the nearshore area because of its tendency to entrap seabirds and seals. This mesh is much larger than anything used in Hawaii. However, as noted

previously, most of Hawaii's fishers use a mesh larger than the allowable two-inch eye. The exceptions to this are primarily recreational fishers.

Fishers also pointed out the importance of considering the catch of adults versus juvenile fish in management of inshore fisheries. While it is presently allowed to catch akule which are considered "undersized" for net fishing with pole and line, this incongruity may need to be reevaluated. As the number of pole and line fishers increases, there will be a need to regulate the taking of undersized fish by all fishers.

Commercial fishers pointed out the effects of the market in regulating the amount and size of the catch. It is primarily because of the preferred market size that fishers use nets with a 2¾" to 3" eye. Furthermore, the market can be easily flooded, at which time fishing activity slows. However, it should be pointed out that the market alone cannot be expected to regulate fishing activity within advisable biological limits.

6) The Enforcement Perspective

Enforcement officers from DLNR's DOCARE also contributed their perspective to the discussion of gillnet regulations. Their input has been incorporated into the recommendations made, but important points are outlined below.

The importance of stipulating rules clearly and unambiguously cannot be over emphasized from the enforcement perspective. The work of enforcement is more effective where rules leave no room for misinterpretation. For this reason, the definition of gears and methods is critical. Delineation of recognizable geographic boundaries in any type of area closure is also paramount to successful enforcement.

DOCARE made it clear that the present 12-hour time limit that nets may be left unattended is unenforceable. Not only is it difficult to interpret the meaning of "unattended"; but even to detect a violation, officers must spend an entire eight-hour shift (and four hours of overtime) watching one fisher. If they attempt to remove the net after the 12-hours and someone comes from anywhere on shore, the net can be considered attended and there is no violation. Not only is the 12-hour limit biologically meaningless, but it is unnecessary to most fishers, and is logistically unenforceable. Thus, a redefinition of how the net should be attended and a shortening of the time limit is imperative.

Enforcement officers also advocated that a method be developed whereby gillnets would eventually be labelled. While this measure will take time to implement, it would impart a sense of responsibility to the net fishers for their gear. Nets are often abandoned for weeks or months at a time, and unless the officers can afford to sit for twelve to thirteen hours there is no way to tell whether the net has been moved or checked. Labelling (and licensing) gear would mean that fishers could be located, warned or cited, if there were any questions about the use of their gear. Nets left for a period of several days or weeks could also be more easily tracked and removed, much like an abandoned vehicle.

7) Additional Information Regarding Sea Turtle Deaths in Gillnets

One of the impacts of gillnet fishing that has not been described is the drowning of endangered marine turtles, which frequent inshore areas to rest and feed on sea grasses. Turtles become entangled in gillnets accidentally and drown as they run out of air struggling to free themselves. This is one reason that actively tending nets is advisable.

A National Marine Fisheries Service Symposium (in Appendix 2) strongly recommended that gillnets be checked at least once per hour to prevent unnecessary turtle mortality. In many areas today, gillnet fishers are required to attend their nets continuously throughout the time they are fishing.

If freed within an hour of becoming entangled, turtles have a good chance of survival. This has been documented in studies in other tropical areas in Florida and throughout Central America. An international symposium on sea turtle biology and fisheries management, held in San Jose, Costa Rica (Appendix 2), summarized information on turtle drowning and described measures developed throughout the world to prevent these incidents. Experts documented that turtles, which normally remain underwater for periods of 30-40 minutes, can be fatally exhausted and weakened after periods of more than an hour in a trawl or gillnet. Drowning occurs more rapidly in tropical environments, where high water temperatures increase the metabolic demand for oxygen. Although a heartbeat can still be perceived for many hours after these events occur, the animals rarely recover and usually die within a few days.

Additional documentation of turtle drowning in gillnets and regulatory measures to prevent this problem are provided in Appendix 2.

IV. CONCLUSION AND RECOMMENDATIONS

A. Discussion and Conclusions

As preface to the recommendations, a general discussion of the reasoning behind these measures is needed. Gillnets have been shown to be a widely used and efficient method of fishing, and one that has a significant impact on inshore fish populations. Resource abundance and fish size increase in areas where gillnetting is restricted. However, it should be understood that any fishery reduces the abundance of the species it targets and abundance is expected to recover when fishing is restricted. Therefore, most of the arguments made against gillnet fishing can be made against any fishing method. This is the reason it is difficult to target restrictions on gillnetting alone.

One of the principal factors supporting gillnet restrictions, and net fishing restrictions in general, is that these methods allocate more of the fishery to a small (undefined) proportion of prospective resource users. The real question is how to balance the harvests of a variety of fishing methods among the users fairly and equitably, and yet prevent overfishing to ensure the continued health of the resource. This is the concept with which the Department and the Legislature have been struggling over the years. Its resolution involves careful consideration and compromise and relies heavily on the participation and representation of all components of the fishery, as well as of fishery scientists.

Differences in the construction of fishing gears over the years have resulted in higher catch rates which, together with the rapidly increasing human population, contribute to the potential for overfishing. Advances in technology are constantly increasing the efficiency of Hawaii's fishers. The replacement of cotton or "linen" gillnets used by early Hawaiians with monofilament nets (which require less maintenance, bring in larger catches, and are less easily perceived in clear water) has made gillnet fishing much more effective. Because the number of inshore gillnetters has increased over the same period, this fishery has reached the point that regulatory measures will be increasingly important to prevent overfishing.

While the need for management is clear, this can be accomplished without banning gillnetting altogether. Fishers have indicated a willingness to reserve certain inshore nursery areas, or to help establish seasonal or annual recovery periods for marine resources on a regional basis. This can be done by establishing FMAs, such as the one in Hilo Harbor, or by a combination of FMA and MLCD measures, as was done in Waikiki. The use of FMAs is preferable, since FMA rules can be tailored to allow some fishing activity. Except for allowing certain types of traditional fishing methods, as discussed during the Administrative Rules process, most fishing activities are prohibited in MLCDs.

If the process of establishing regional FMAs to protect certain areas from overfishing by gillnets is undertaken in a forum open to public input, the result will be a system that fishers respect and support. This will reduce the amount of enforcement necessary, since fishers will stand by measures undertaken with a full understanding of the need for management to protect the resources all of Hawaii's residents share.

The following recommendations apply to gillnets, as described and listed above the bold black line in Table 1. Recommendations for the regulation of gillnetting in Hawaiian waters are discussed in three phases:

1) The first phase is designed to address, problems with existing rules and their enforcement.

2) The second phase, which should be planned during Phase I, includes a number of measures that should be developed over a 1-2 year period, but which will be more effective and have a greater assurance of widespread acceptance if sufficient time is taken to evaluate the present situation carefully, tailor the measures to the specific needs of Hawaii and develop a consensus through statewide consultation with a broad group of inshore fishers (including gillnetters).

3) The third phase includes longterm measures which are based on major changes in the way the gillnet fishery is registered and managed. Implementation of these measures cannot happen without careful planning and coordination of administrative and enforcement aspects, as well as consultation and coordination with the fishing community (which begins during Phase II).

The full range of recommendations is presented at this time to provide a vision for the protection Hawaii's inshore living marine resources, as well as the future of the inshore gillnet fishery.

Phase I: Correction of problems with existing rules

It is recommended that the time a gillnet may be left unattended should be limited to two hours. This measure should apply within State waters. More important than attending gillnets (merely watching them), is to visually inspect the net every two hours and release or remove any undersized, illegal or unwanted catch. It is understood that any wanted catch will be removed and stored or iced.

The rationale behind this recommendation is that much of the catch is wasted if nets are checked less often. Fish become spoiled, half-eaten by predators and unmarketable; and endangered species, such as marine turtles are drowned unnecessarily.

If the above measure alone is implemented, fishers could still conceivably leave a gillnet out for days or weeks at a time provided they check the net every two hours and release unwanted or dying fish. This would not reduce the impact of having nets indefinitely blocking the movement of fish through any given area. Therefore, it is recommended that measures be developed to require gillnets to be removed from the water after fishing for a determined number of hours. Discussions with fishers, biologists and enforcement officers suggest this limit should be between 2-4 hours. The definition of a precise time limit should be taken up with other issues to be addressed in statewide public meetings.

Fishers have noted that nets left in the water for too long begin to accumulate debris, and function as a barrier rather than a sieve. Beyond ensuring that nets do not become encrusted, or block fish passage indefinitely, restricting the amount of gillnet fishing by everyone during any 24-hour period would reduce fishing effort on the whole statewide. Clearly the decline in abundance of inshore resources indicates that such measures are needed.

However, this measure will be difficult to enforce until nets are clearly labelled and their owners identified. Therefore, it can only be enforced during Phase III and would have to be held for full implementation until nets are labelled. The recommendation is noted in the discussion of the basis for Phase I recommendations, but enabling legislation will have to be designed and implemented following completion of Phase III.

Phase II: Measures that should be developed over a 1-2 year period, following a full evaluation of the present situation to include statewide consultation with a broad group of Hawaii's inshore fishers

There is clearly a need for localized area closures in some embayments, estuaries and/or open coastal areas. Both the need for and the number of feasible sites varies on an island-wide and seasonal basis; therefore, these measures should be worked out regionally. Some areas may need to be protected indefinitely, or until such time as significant recovery is achieved. An effort should be made to develop recommendations that will ensure that some accessible areas of the coast will be open to fishing at any given time. Areas selected must have strictly defined geographic boundaries, and may include a seasonal or annual component.

The establishment of localized area closures should be among the first issues to be evaluated statewide. This evaluation should include intra-agency (DAR and DOCARE) and public meetings, other scientific input, mail or phone surveys, and opportunities for freestyle write-in comment. An effort should be made to obtain a representative sample of Hawaii residents, to accurately record the proportion of respondents as a function of their input, to avoid repeated input by the same individuals or interest groups, and to verify that participants in the evaluation are residents. There should be no requirement that those providing input speak publicly. A special effort should be made to involve gillnetters and other fishers in the development of recommendations, as well as to create an informed dialogue between divergent viewpoints, to encourage progress toward consensus. These measures would ensure that all of Hawaii's residents have an opportunity to be heard in an atmosphere that is comfortable for everyone.

The second goal during Phase II, should be to determine and legally implement a new minimum allowable mesh size for gillnets. The present two-inch mesh size should be changed to a minimum of 2¾ or 3 inches. A time lag is recommended in order to adequately determine the exact mesh size needed, since changing their present fishing gear will mean an expense to fishers that should be implemented unequivocally. Most serious fishers already use a minimum mesh of 2¾ inches. However, the State should make certain the proper mesh size is implemented, to avoid the need for further change.

Careful planning is necessary to ensure a smooth transition from one mesh size to another, as illustrated by Hawaii's experience with enlargement of thrownet meshes (from 1½" to 2"), which will have taken about eight years to implement fully in 1994. Buy-back programs have been successful in other states and provide an additional incentive to fishers to comply with the rules without penalty. A grace period could be set, within which small-meshed nets could be exchanged for legal meshes at little or no cost. Such a program would require funding, but the longterm trade-offs might well be worth it. Federal funds might be sought for such a program, which would ultimately benefit the nearshore ecosystem as well as the fishery.

The third measure to be developed during Phase II would be to establish reporting requirements for recreational fishers using nets over a specified length (about 250-500 ft), as suggested by the Kaneohe Bay Task Force. Fishers using nets over this length should be required to report, regardless of whether or not they sell their catch,

since their nets catch enough to have a significant impact on the resource. This is illustrated by the catch of a single gillnet registered during creel surveys at the Waikiki-Diamond Head FMA. The State needs to have access to information on catches of this magnitude, in order to assess the impact of gillnetting.

Phase II should also include planning for the implementation of a net permitting and labelling program. All gillnets used in State waters should be permitted. The permitting process would include labelling of gear, typically by a visibly numbered float and tag system. The labelling system would have to be developed with the assistance of the DOCARE, to ensure that identification from shore would be rapid and practical. A computerized database could be developed within DOCARE, including the owner's address and contact number. This system would function much like the State's motor vehicle licensing system, or the US Coast Guard's "HA" numbering system for marine vessels. With such a system in place, the owner of a net left unattended could be warned and/or cited, thereby reducing violations over the long term. It is human nature to occasionally exceed the recommended time in a given area, whether it be a parking meter or a coastal fishing area. A permitting system would make it possible to identifying repeat offenders and focus enforcement efforts only where they are really necessary.

Phase III: Longterm measures requiring changes in the way the fishery is registered and managed

As discussed under Phase I recommendations, the key to being able to manage Hawaii's inshore gillnet fishery is the development and implementation of a plan to permanently label all gillnets and identify gillnet fishers. Until such measures are developed, management will have to be on an area-specific basis, since it is not practical to sit and watch fishers for hours on end in order to determine whether the gear is being used legally.

Thus, by Phase III, all gillnets in the State should be labelled and permitted, with identification of ownership. Only then can the issue of limiting the number of nets and fishers be approached on a coastal carrying capacity basis. Once all gillnets are labelled, measures such as a rotating permit system (to reduce effective fishing effort in any given month or year) can be considered. Before this is done, questions such as the length of net per owner and what to do about groups of recreational fishers who fish in groups with several pieces of net joined together must be addressed.

While gear labelling is being implemented, studies should be conducted to determine the amount and length of gear that should be allowed to fish in Hawaii on a regional basis. This entails biological assessments, periodic estimates of resource abundance and determination of gear-specific fishing mortality. All these considerations will be well within the grasp of the DAR in the next few years, through research conducted as part of the MHI-MRI.

B. Proposed Enabling Legislation to Regulate the Use of Gillnets

Measures recommended for immediate implementation are as follows:

1) HRS §188-30.2. should be amended to read:

"Fishing with gillnets.

(a) It is unlawful for any person engaged in gillnet fishing within State waters to leave the person's net unattended for a period of more than two hours, without visually inspecting the net every two hours and releasing or removing any undersized, illegal or unwanted catch."

The second part of this measure, to be implemented once nets are labelled and a precise length of time a gillnet can be used is agreed upon, would read:

(b) It is unlawful for any person to engage in gillnet fishing in State waters for more than (2-4) hours during any 24-hour period.

2) For the above measures to be meaningful, a definition of gillnet fishing must be entered into Hawaii Revised Statutes. It is recommended that the following definition (condensed from page 3), precede gillnet regulations in HRS:

"The gear: An ordinary gillnet consists of a single wall of webbing, connected to a float line at the top and a sink line at the bottom. The gillnet hangs vertically in the water by means of its floats and sinkers. A buoy and/or marker is usually attached to the float line at one end and some form of anchor is placed at either or both end(s) of the lead line. Gillnets are made of a variety of materials, including cotton, linen and nylon, but are commonly made of translucent monofilament (plastic) line, varying in thickness, transparency and strength.

The method: Fish are captured in a gillnet by the mesh of the net. In trying to swim through, they are able to get the head through, but not the whole body. In trying to back out, the twine of the mesh slips under the gill cover preventing escape. Fish too large to get the head in or small enough to swim through are not captured, unless entangled by their fins or other bony projections on their bodies."

Information from Table 1 could be used to enhance this definition.

3) A statewide evaluation should be conducted to develop a plan to mitigate the impacts of inshore gillnet fishing. Public meetings would use the guidelines set forth in this document as a point of departure, so as to encourage a conservation ethic and reach a more rapid consensus with the assistance of the public. Discussions should include a representative cross section of inshore gillnet fishers and the general public. The plan should be presented to the Legislature for implementation within two years, and should include:

a) Well-defined geographic and/or seasonal boundaries for FMAs on the islands of Kauai, Oahu, Molokai, Maui and Hawaii, with specific recommendations for restrictions to gillnetting as necessary.

b) A maximum length for recreational gillnets, with reporting requirements for gillnet fishers' nets that exceed this length (about 250-500 ft), and;

c) A new minimum allowable mesh size of about 2¾ to 3 inches,

Milestones should be set forth at two and five-years, for development and implementation of phases II and III of the plan, to encourage rapid progress toward full management and assessment of Hawaii's inshore gillnet fishery.

APPENDIX 1: ESTIMATES OF FISH ABUNDANCE AND DIVERSITY FROM DIVE SURVEYS AT THE WAIKIKI-DIAMOND HEAD FMA/MLCD COMPLEX 1978-92

Fiscal Year	Number of (Monthly) Surveys Conducted	ESTIMATED FISH ABUNDANCE No.Fish/Acre		ESTIMATED FISH BIOMASS (Lbs/Acre)		MEAN NO. SPECIES REGISTERED
		Mean	Std[9].	Mean	Std.	
1978	12	844.1	196.6	116.7	65.5	50
1979	12	1147.2	134.9	250.8	80.8	62
1980	11	1735.1	405.4	507.9	102.8	69
1981	12	1230.0	325.3	295.9	115.1	70
1982	11	1091.7	410.7	182.6	105.7	49
1983	12	1450.2	511.1	364.7	327.8	62
1984	12	1697.8	267.1	584.7	423.3	78
1985	11	1676.5	933.6	272.5	97.9	66
1986	11	1088.7	177.4	191.0	68.5	64
1987	9	1563.2	322.8	317.0	99.6	68
1988	4	1290.3	517.0	249.0	118.9	75

[9] Standard deviation.

APPENDIX 2:
INFORMATION ON TURTLE DROWNING IN GILLNETS

A DOCUMENTED CASE OF GREEN TURTLES KILLED IN AN ABANDONED GILL NET: THE NEED FOR BETTER REGULATION OF FLORIDA'S GILL NET FISHERIES

Llewellyn M. Ehrhart
P. Raymond
Jamie L. Guseman
R. Owen
Department of Biological Sciences, University of Central Florida, Orlando, FL 32816 USA

The strandings of juvenile green turtle carcasses are common events along the southeast Florida coast. In the past two years at least 266 green turtles (most of them juveniles) have stranded in the six-county area from Brevard to Broward. These green turtles seem to have been ignored in the following two ways. First, we have failed to account for them in our attempts to model the ecologic geography of Western Atlantic green turtles. They have not, in other words, been assigned to a recognized life history stage. It's not that this neritic population of green turtles is completely unstudied. Over the past few years Martin and Ernest, working in Martin County, have suggested that the extensive near-shore reef system should be recognized as an important transitional habitat, used extensively by green turtles prior to entry into the lagoon system. Similarly, the Wershovens have documented the use of near-shore reefs by green turtles in Broward County.

J. L. Guseman and I have recently begun to study the population of green turtles on the reefs off northern Indian River County. Guseman's paper, presenting preliminary biological results, appears elsewhere in this volume. It is, however, important to point out here that there are rocky, algae-covered reefs, built by Sebellariid polychaete worms, all along the southeast Florida coast. There is now reason to believe that a large assemblage of young green turtles resides on these reefs and that the reefs constitute a previously unrecognized developmental habitat.

The second way that we have ignored these southeast Florida green turtles is that we have taken a languid approach to their conservation and management. The numbers to the right of the east coast counties on Figure 1 indicate the minimum number of green turtle carcasses known to have stranded there in 1988 and 1989. The numbers rise sharply in the counties with near-shore reefs. The principal cause of the mortality reflected in these numbers appears to be drowning in the nets of two types of gill net fisheries. Until now, however, there has been little proof.

On 16 October 1989, the Florida Marine Patrol received reports of a gill net abandoned over the reef in northern Indian River County, off the town of Wabasso. A Coast Guard cutter was summoned from Ft. Pierce to retrieve the net, which was estimated to be >1000 yds. As the net was pulled over the high gunwales of the cutter, many carcasses fell into the water. How many were turtles is unknown.

In addition to a large number of dead stone crabs, Florida lobsters, and various cartilaginous and bony fishes, there were 10 green turtle carcasses and parts of one loggerhead. The dead green turtles ranged in carapace length from 27.0 to 58.2 cm. Morphometric data for these greens were statistically similar to those of the live green turtles we had been capturing and tagging nearby on the reef (Figure 2).

Another documented case of the killing of green turtles by a gill net occurred during the period from 9 to 11 February 1990, in Brevard County. In this case at least four greens died in a net set a few hundred yards off the beach at Patrick Air Force Base.

There is another gill net fishery off the southeast Florida coast that threatens turtles. It is the drift net fishery for king mackerel and sharks. It takes place farther off-shore, in federal waters which begin three miles out. The huge nets that are employed are often >4000 yds long and are hauled back by powered "hi-rollers." Occasionally the nets (or parts of them) are lost and become ghost nets, catching many things, including sea turtles, over

the nets (or parts of them) are lost and become ghost nets, catching many things, including sea turtles, over long periods.

The peak period for drift netting for "kings" is April-May, and the season is closed November through March. During the closed season, however, the fishermen switch to larger-mesh nets, which are probably more dangerous to turtles, and fish for sharks. We know comparatively little about this fishery. One observer-based study of the fishery at Ft. Pierce produced results that were useful up to a point. It appears to us that encounters with marine turtles may have gone unnoticed, however. As a result, we are calling for the implementation of effective observer programs, carried out by adequately-trained observers throughout the year, in both the near-shore pompano fishery and the off-shore drift net fishery.

We offer the following further suggestions:

1) For both fisheries there should be tighter regulations regarding identification and/or registration of nets;
2) Gill netters should be required to "tend" their nets while they are soaking, as they do in the lagoon, and nets should be checked at least once per hour;
3) Any net left unattended should be considered abandoned, and officials should be authorized to pull and destroy it. Currently that is apparently not the case in Florida.

CONCLUSION

There is an important assemblage of green turtles living over the reefs along the southeast Florida coast. These turtles are threatened by a near-shore gill-net fishery, primarily for pompano. Turtles are also threatened farther off-shore by the drift net fishery for king mackerel and sharks. We urge the conservation organizations to recognize this problem and take action. Also, state and federal agencies should, at the very least, begin effective observer programs and move quickly to install regulations that will protect this important green turtle population.

NOAA Technical Memorandum NMFS-SEFC-278

PROCEEDINGS OF THE TENTH ANNUAL WORKSHOP ON SEA TURTLE BIOLOGY AND CONSERVATION

20-24 February 1990
Hilton Head, South Carolina

Compilers:
Thelma H. Richardson
James I. Richardson
Marydele Donnelly

AUGUST 1990

U.S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
John A. Knauss, Administrator

NATIONAL MARINE FISHERIES SERVICE
William W. Fox, Jr., Assistant Administrator for Fisheries

AGENDA
DEPARTMENT OF NATURAL I
JUNE 12, 1991

MARINE FISHERIES COMMISSION

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Item A Gear Specifications for Certain East Coast Counties — Rule 46-4.007

Consideration of proposed Rule 46-4.007, F.A.C., relating to gear specifications for certain east coast counties to reduce sea turtle mortality.

PURPOSE AND EFFECT: The breeding population in Florida of the green sea turtle, *Chelona mydas*, is listed as endangered under the Endangered Species Act of 1973, 16 U.S.C. 1531 *et seq.* This species has been placed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and is listed as endangered throughout its range by the International Union for the Conservation of Nature and Natural Resources (IUCN). Direct and indirect harvest of this species and degradation of nesting and feeding habitats are thought to be responsible for continuing declines in green sea turtle populations. Human-induced mortality has already caused the extinction of nesting populations in Bermuda and the Cayman Islands.

Sea turtles are vulnerable to entanglement and drowning in gill and trammel nets, especially when this gear is left untended. In January, 1991, an alarming number of green sea turtle strandings in a five county area on the east central coast of Florida were reported to the Marine Fisheries Commission. The Commission concluded that many of these strandings resulted from interaction between gill and trammel nets fished in the area and the juvenile green sea turtles frequenting the developmental habitat provided by near-shore reefs. A significant factor in the sea turtle mortality associated with this interaction was found to be the deployment of excessive lengths of gill and trammel nets, more than can reasonably be expected to be adequately tended by the fishermen. Emergency Rule 46ER91-1 was adopted by the Commission to address the short term problem with green sea turtle mortality by limiting the length of gill and trammel nets to 600 yards, prohibiting the use of more than one such length of net, and requiring that all nets be tended and marked to provide ready identification.

This proposed rule provides similar, though more detailed, permanent restrictions on gill and trammel net fishermen in the five-county area to limit the adverse impacts of such gear on these endangered animals. Near-shore and inshore net fishing generally proceeds year-round in the area, where green sea turtles are constantly present. Additionally, a portion of a Martin County special act, Chapter 71-770, Laws of Florida, is being repealed and a prohibition on hauling nets upon the shore in inside waters from the local law is readopted.

SUMMARY: Subsection (1) provides for application of the rule in the state waters of Brevard, Indian River, St. Lucie, Martin, and Palm Beach Counties. An exception is made for persons in transit through state waters to fish in and return from federal waters. Paragraph (1)(a) prohibits use of a gill or trammel net longer than 600 yards. Paragraph (1)(b) prohibits possession of more than two such nets aboard a vessel at any time and prohibits the fishing of more than one net from a single vessel at any one time. Paragraph (1)(c) the fastening together of two or more nets to exceed the total length limit specified in Paragraph (1)(a). Paragraph (1)(d) requires that each net fished be tended. Paragraph (1)(e) requires that all nets either possessed aboard a vessel or fished must be marked in a prescribed manner for identification purposes and for navigation and enforcement at night.

Subsection (2) of the rule provides a definition of the term "tend", and includes within the definition a one-hour soak time maximum. Subsection (3) states the intent of the Commission not to supersede laws or rules that close areas or limit gear, except as provided for in subsection (4) of this rule with respect to a Martin County special act.

Paragraph (a) of subsection (4) accomplishes the repeal of section 6 of Chapter 71-770, Laws of Florida, a special act pertaining to Martin County. This special act was made a rule of the Department of Natural Resources by the Commission's enabling law. Paragraph (b) of the subsection prohibits the hauling upon the shore of any gill or trammel net in the inside waters of Martin County. Paragraph (c) states a finding of the Commission that the repeal of section 6 of Chapter 71-770, Laws of Florida, will not adversely affect the marine resources of Martin County or the state.

Notice of proposed rulemaking was published in the April 12, 1991 issue of the Florida Administrative Weekly. A Petition for Administrative Determination of Invalidity of Proposed Rule was filed with the Division of Administrative Hearings on April 29, 1991, by the Center for Marine Conservation. Pursuant to Section 120.54(9), Florida Statutes, Emergency Rule 46ER91-1, addressing the same subject as the proposed permanent rule, was renewed by notice published in the May 10, 1991 issue of the F.A.W., pending effectiveness of Rule 46-4.007. A public hearing on the proposed rule was held by the Commission on May 10, 1991, in Tallahassee. As a result of changes made to the rule at the hearing, the Center for Marine Conservation has agreed to withdraw its challenge to the proposed rule if the Governor and Cabinet approve it. Notice of the changes made to the rule and of this meeting of the Governor and Cabinet were published in the May 24, 1991 issue of the F.A.W.

RECOMMEND: APPROVAL

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Rash of Green Turtle Beach Strandings Brings Emergency Restrictions on Nets

During the last week of January, at least 14 dead sea turtles washed ashore in St. Lucie, Martin and Indian River Counties, apparently the victims of encounters with a gauntlet of nets put down by commercial fishermen seeking valuable pompano. Reacting quickly, the Florida Marine Fisheries Commission and the Florida Cabinet enacted an emergency rule that will regulate nets in the area for 90 days.

The multiple deaths caused the incident to be headlined in newspapers, touching off a statewide outcry from both the conservation community and the general public.

Sadly, however, the only unusual aspect was the high number of strandings in a short period of time. The killing of juvenile turtles by commercial nets in that area is so common that one scientist—environmental specialist Barbara Schroeder of the Florida Marine Research Institute in Stuart—says it "represents a threat to the recovery of this endangered species."

In 1990, at least 110 juvenile green turtles were killed in Brevard, Indian River and St. Lucie Counties, and the 14 victims found during the last week of January brought 1991's early total to a whopping 31.

Entanglement in gill nets, with resultant drowning, seems to be the cause of death in most cases.

"We can't document that all the kills were caused by nets," Schroeder says, "But we have concrete evidence of their involvement in many cases."

Other biologists noted that strandings of young green turtles almost always follow a period of heavy netting activity in waters close to shore.

The January surge of turtle deaths came during a frantic crush of netting for pompano, one of the highest priced of all market fish, just off the beaches. An observer in Stuart reported that the fishery has become far overcrowded since the development of a new type of monofilament that allows nets to lie so flat that even a small boat can carry and work a net more than 3000 yards long—two miles or so.

But the small boats weren't alone. Roller-rig boats with huge nets and storage capacities joined the fishery too, and commercial vessels of all sizes swarmed to the Treasure Coast from other parts of the state.

One local netter, shaking his head at the mountain of competition heaping up in front of him, said, "You can't find a place to make a set from Martin County to the Cape (Canaveral)."

Aside from the devastating effect on turtles, local fishermen fear that the immense amount of gear in the water will soon collapse the pompano fishery.

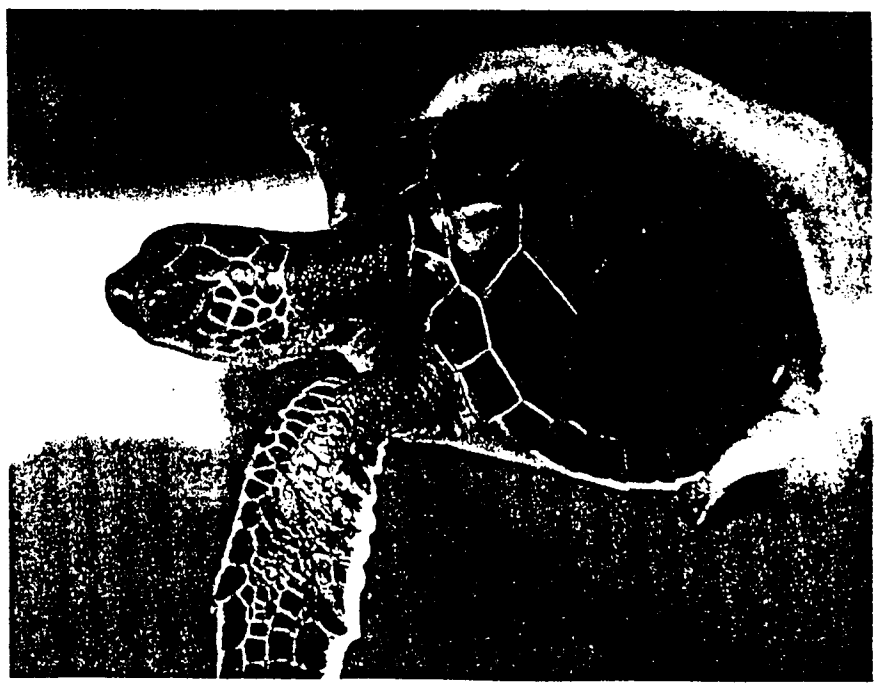
It was also observed that the nets were piling up a huge bycatch of large Spanish mackerel. Since the mackerel hauls often exceeded commercial trip limits, it was common for netters to reset their nets and leave them unattended while they ran back and forth to the fishhouses to unload their mackerel.

Snapper and assorted bottom fish are also taken in the net fishery. The nets are set on top of the water but over shallow reefs where the young turtles live, which accounts for the heavy toll on them. An additional problem is that the nets sometimes snag on the reefs and become "ghost nets" that add to the mortality on both fish and turtles.

The MFC's emergency rule, which went into effect in mid-February, placed a limit of 600 yards (about a third of a mile) on gill and trammel nets off the coasts of Brevard, Indian River St. Lucie, Martin and Palm Beach Counties. Although two such nets are allowed on a boat, only one may be fished at a time —and it must be specially marked and attended constantly.

Commenting on the rule, environmental specialist Schroeder said simply, "They did the right thing."

Ted Forsgren of the Florida Conservation Association praised the field scientists, the Department of Natural Resources, the MFC and the Governor and Cabinet for their swift and decisive response to the netting excesses. But while applauding the emergency rule he emphasized that it will end in 90 days, and said that "permanent and more comprehensive measures need to be taken to prevent gill and trammel nets from killing sea turtles."



Will this little green turtle escape commercial nets long enough to grow up?

MANUAL OF SEA TURTLE RESEARCH
AND CONSERVATION TECHNIQUES

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MANUAL OF SEA TURTLE RESEARCH AND CONSERVATION TECHNIQUES

AUTHORS

Peter C. H. Pritchard
Florida Audubon Society
1101 Audubon Way
Maitland, Florida 32751 U.S.A.

Peter R. Bacon
Zoology Department
University of the West Indies
Box 12 Mona
Kingston, Jamaica

Frederick H. Berry
Southeast Fisheries Center
National Marine Fisheries
Service, NOAA
75 Virginia Beach Drive
Miami, Florida 33149 U.S.A.

Archie F. Carr
Department of Zoology
University of Florida
Gainesville, Florida 32611 U.S.A.

John Fletemeyer
Ocean Sciences Center
Nova University
Dania, Florida 33004 U.S.A.

Robert M. Gallagher
Chemical and Environmental
Sciences, Inc.
1038 NE Hansen Terrace
Jensen Beach, Florida 33457 U.S.A.

Sally H. Hopkins
South Carolina Wildlife and Marine
Resources Department
P.O. Box 12559
Charleston, South Carolina 29412 U.S.A.

Robert R. Lankford
IOC Assistant Secretary for
IOCARIBE
c/o UNDP
Apartado 04540
San Jose, Costa Rica

Rene Marques M.
Instituto Nacional de Pesca
Delegacion Federal de Pesca
Teniente Azueta S/N
Manzanillo, Col. 28200, Mexico

Larry B. Ogren
Southeast Fisheries Center
National Marine Fisheries
Service, NOAA
Panama City Laboratory
3500 Delwood Beach Road
Panama City, Florida 32407 U.S.A.

William G. Pringle, Jr.
1 Notch Road
West Simsbury
Connecticut 06092 U.S.A.

Henry A. Reichart
STINASU
PO Box 436
Paramaribo, Suriname

Ross Witham
Florida Department of
Natural Resources
100 Eighth Avenue, S. E.
St. Petersburg, Florida 33701
U.S.A.

D.2 Incidental Catch

D.2.1 Background

In some areas, incidental catch appears to be a major mortalit factor for sea turtles. Turtles that become trapped in nets durir shrimp trawling and fish seining may be injured or drowned. In additic to being an obvious problem for turtles, their incidental catch ma interfere with commercial fishing operations and damage the gear.

D.2.2 Avoidance of Incidental Catch

This problem may be partly if not completely avoided and, conse quently, the mortality reduced in three ways:

a) Areas frequented by large numbers of turtles can be identifie and fishing activity in such areas restricted. Restrictions ma be necessary only during certain seasons if the turtles concen- trate for feeding or nesting only. Some shore-based fisherme who set nets near the beach leave their nets set during the night to ease their work load. Turtles are often caught on their way in to the nesting beach. In Suriname, fishermen have cooperated willingly by raising their nets at night after the problem was explained to them.

b) Trawl nets and other fishing gear should be pulled up more fre- quently. A turtle rescued from a net in less than one hour of trawling normally has a good chance of survival.

c) Use of an excluder device on trawl nets reduces incidental catch significantly. The most effective device uses a trap door in the top of the trawl that opens to release large, heavy objects such as turtles and then closes again. Information on this can be obtained from the Southeast Fisheries Center, National Marine Fisheries Service, 75 Virginia Beach Drive, Miami, Florida 33149, U.S.A. Request NOAA Technical Memorandum NMFS, SEFC-71 which contains detailed instructions on how to assemble, install and use an excluder device made from easily obtainable material.

D.2.3 Resuscitation of Apparently Drowned Sea Turtles

The time it takes to drown a turtle held under the surface by a trawl or other net is variable. The metabolism, and thus the oxygen demand, of a submerged turtle depends upon several factors, principally ambient temperature and activity level. Turtles caught in very cold waters, particularly dormant individuals dredged from winter hibernation sites, probably have a low oxygen demand and can survive for some time in a trawl. On the other hand, a turtle caught in a trawl in the trop- ics or in temperate zones during the summer has a high temperature, a higher metabolism and thus a shorter survival time in a trawl net. In addition, efforts to outswim an approaching net and struggles to free itself once trapped further increase its oxygen demand and dangerously shorten survival time.

Sea turtles caught in set nets or trawl nets may appear dead when brought to the surface or on the deck of a vessel. These animals do not move and their breathing and heartbeat cannot be observed without special instruments. Apparently lifeless turtles, however, may not actually be dead but may be moribund (approaching death). Field observations have demonstrated that many are only comatose and often may be revived.

To resuscitate an apparently comatose or drowned turtle, place it belly-down on the deck. Prop up the rear end so that the head is consi- derably lower than the tail. In this position, gravity can draw the water out of the turtle's lungs. Place the turtle in shade. An alter- native resuscitation method is to place the turtle on its back and repeatedly push on the plastron with the foot to force the water from the lungs. However, some turtles, for reasons that are still poorly understood, die of anoxia without ever drawing water into the lungs while forcibly submerged. Comatose turtles will die if returned to the sea. Keep any apparently lifeless sea turtle out of the water for at least 24 hours and practice resuscitation, if possible, for 24 hours before presuming the turtle dead.

Sea turtles caught in nets and brought to the surface from very cold waters (less than 14°C) may have been hibernating in bottom mud. They may be dormant or comatose. If they are simply thrown back to the cold water, some or all of them might die from hypothermal stress. Until the physiology of this apparent hibernation is more thoroughly researched and understood, protect any sea turtles brought up from cold waters by temporarily storing them in warmer water before returning them to the sea.

from the seasonal patterns only by a simple linear regression analysis. More incisive analyses, as presented below, are needed to tease apart the relationship.

Strong Evidence of Shrimp Trawling as an Agent of Sea Turtle Mortality

One central charge of this committee is to evaluate available evidence to assess whether incidental catch of sea turtles during shrimp trawling is indeed a cause of sea turtle mortality and, if so, to estimate the magnitude and importance of this mortality. Sea turtles are undoubtedly caught in large numbers during shrimp trawling. For example, the primary source of tag returns from female Kemp's ridleys tagged at the nesting beach at Rancho Nuevo (84% of 129 returns) has come from incidental capture of the turtles and reporting of tag numbers by cooperative shrimpers (Pritchard and Márquez M., 1973; Márquez M. et al., 1989). Furthermore, observers on vessels conducting commercial shrimp trawling have reported large numbers of sea turtle captures (Hillestad et al., 1978; Roithmayr and Henwood, 1982).

Even if individual fishermen catch few turtles, the size of the shrimp fleet and the effort exerted result in a collective catch that is "large," although not all sea turtles that are caught in shrimp trawls necessarily die as a result. In a recent review, 83% of 78 papers on the incidental capture of all Atlantic sea turtle species in fishing operations inferred that shrimp trawling is a major source of mortality (Murphy and Hopkins-Murphy, 1989).

We consider below five observations that, when taken together, constitute a compelling demonstration that incidental capture during shrimp trawling is the proximate cause of mortality of substantial numbers of sea turtles.

Relation Between Sea Turtle Mortality in Trawls and Tow Time The most convincing data available to assess whether shrimp trawling is responsible for sea turtle deaths come from NMFS studies relating the time that a trawl was allowed to fish (tow time) to the percentage of dead sea turtles among those captured. Henwood and Stuntz (1987) published a linear equation showing a strong positive relation between tow time and incidence of sea turtle death. They concluded that "the dependence of mortality on tow time is strongly statistically significant ($r = 0.98$, $p < 0.001$)."

The committee analyzed the data set used by Henwood and Stuntz to clarify in detail the relationship between tow times and mortality. Death rates are near zero until tow times exceed 60 minutes; then they rise rapidly with increasing tow times to around 50% for tow times in excess

of 200 minutes. That pattern is exactly what would be expected if trawling were causing the drowning of an air-breathing animal. Death rates never reach 100%, because some turtles might be caught within 40-60 minutes of lifting the net from the water. The data provide the functional relation between other correlative relations, namely, between fishing activity and dead turtles or population trends.

Under conditions of involuntary or forced submergence, as in a shrimp trawl, sea turtles maintain a high level of energy consumption, which rapidly depletes their oxygen store and can result in large, potentially harmful internal changes. Those changes include a substantial increase in blood carbon dioxide, increases in epinephrine and other hormones associated with stress, and severe metabolic acidosis caused by high lactic acid concentrations. In forced submergence, a turtle becomes exhausted and then comatose; it will die if submergence continues. Physical and biological factors that increase energy consumption, such as high water temperature and increased metabolic rates characteristic of small turtles, would be expected to exacerbate the harmful effects of forced submergence because of trawl capture.

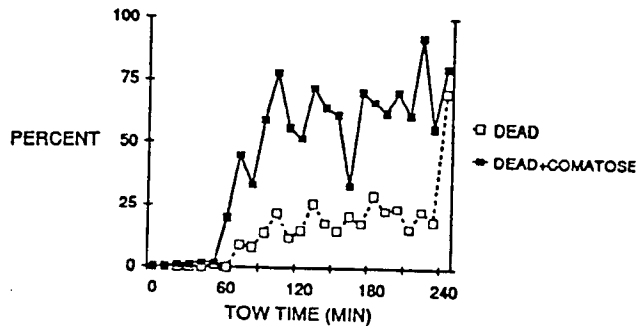
Drowning can be defined as death by asphyxiation because of submergence in water. There are two general types of drowning: "dry" and "wet." In dry drowning, the larynx is closed by a reflex spasm, water is prevented from entering the lungs, and death is due to simple asphyxiation. In wet drowning, water enters the lungs. For nearly drowned turtles, the wet type would be more serious, because recovery could be greatly compromised by lung damage due to inspired seawater. The exact mechanism of sea turtle drowning is not known, but a diagnostic condition of the wet-drowning syndrome—the exudation of copious amounts of white or pink froth from the mouth or nostrils—has been observed in trawl-captured turtles.

Turtles captured in shrimp trawls might be classified as alive and lively, comatose or unconscious, or dead. A comatose turtle looks dead, having lost or suppressed reflexes and showing no sign of breathing for up to an hour. The heart rate of such a turtle might be as low as one beat per 3 minutes. Lactic acid can be as high as 40 mM, with return to normal values taking as long as 24 hours. It takes 3-5 hours for lactic acid to return to 16-53% of peak values induced by trawl capture. Although the fate of comatose turtles directly returned to the sea is unknown, it is reasonable to assume that they will die (Kemmerer, 1989).

In 1989, NMFS conducted a tow-time workshop to analyze data on tow times and turtle conditions from seven research projects. The projects spanned 12 years, during which 4,397 turtles were encountered. The numbers of dead and comatose turtles increased with tow time (Figure 6-3). Small increases in tow time between 45 and 125 minutes resulted in large, steep increases in the numbers of dead and comatose turtles. For most tow times, there were more comatose than dead turtles. Few turtle deaths were related to tow times of less than 60 minutes. Tow times are thus a critical element in determining turtle mortality associated with shrimp trawls.

Coincidence of Opening and Closing of Shrimp Season with Changes in Turtle Stranding on Adjacent Beaches in Texas and South Carolina Murphy and Hopkins-Murphy (1989) used the data on sea turtle stranding in South Carolina in 1980-1986 to seek a temporal relation between the opening of the ocean shrimp fishery and the rate of stranding. In South Carolina, the Sea Turtle Stranding and Salvage Network (STSSN) has provided complete and reliable coverage of the ocean beaches for several years. The opening of the ocean shrimp fishery took place between May 16 and June 26 and varied from year to year. The 7-year total number of strandings (190 carcasses) in the 2-week periods just after the opening of the fishery was 5 times as large as the number of strandings in the 2-week periods immediately before the opening (38 carcasses). Although that does not conclusively demonstrate a causal relationship, repetition of the

FIGURE 6-3 Relation between the percentage of dead or dead and comatose loggerheads as a function of tow time of trawls. Total number of turtles captured was 4,397. Compiled by the committee from raw data provided by NMFS that were the basis for Henwood and Stuntz's (1987) calculations.



DECLINE OF THE

SEA TURTLES

CAUSES AND PREVENTION

Committee on Sea Turtle Conservation

Board on Environmental Studies and Toxicology

Board on Biology

Commission on Life Sciences

National Research Council

NATIONAL ACADEMY PRESS
Washington, D.C. 1990

HOUSE OF REPRESENTATIVES
SIXTEENTH LEGISLATURE, 1992
STATE OF HAWAII

H.C.R. NO. 421 H.D.1

HOUSE CONCURRENT RESOLUTION

URGING THE DEPARTMENT OF LAND AND NATURAL RESOURCES TO ASSESS THE IMPACT OF GILL NETTING IN STATE WATERS AND PROPOSE REGULATIONS TO CONTROL OR RESTRICT THE USE OF GILL NETS.

WHEREAS, balanced populations of fish contribute to the stability of Hawaii's nearshore ecosystem, maintenance of environmental quality, economic productivity of Hawaii's waters, and to the underwater pleasure that is enjoyed by residents and visitors alike; and

WHEREAS, in the past, the Department of Land and Natural Resources has documented that the use of gill nets has indiscriminately removed fish from the nearshore ecosystem and has thereby seriously depleted and harmed nearshore fishery resources; and

WHEREAS, Hawaii is the only state in the nation that permits recreational gill netting and permits a two-inch minimum mesh eye size for gill nets, which may be set overnight and left unattended for up to twelve hours; and

WHEREAS, current studies being conducted by the Department of Land and Natural Resources of Hawaii's nearshore fishery resources could augment past documentation to yield enough data to reach a general evaluation of the impact of gill net use; now, therefore,

BE IT RESOLVED by the House of Representatives of the Sixteenth Legislature of the State of Hawaii, Regular Session of 1992, the Senate concurring, that the Department of Land and Natural Resources prepare a report on the use of gill netting in state waters which will include, but not be limited to:

(1) An assessment of the impact of nearshore gill netting on Hawaii's fishery;

(2) Recommendations on the adoption of new or alternative rules or regulations, if needed, which would mitigate the impact on nearshore fishery resources, such as changing the eye mesh size of gill nets, the overall length of such nets, and the duration of time for which the nets may be left unattended; or,

(3) Propose enabling legislation, if necessary, to regulate, control, or restrict the use of gill nets; and,

BE IT FURTHER RESOLVED that the Department of Land and Natural Resources submit its findings and recommendations to the Legislature no later than twenty days prior to the convening of the Regular Session of 1993; and

BE IT FURTHER RESOLVED that a certified copy of this Concurrent Resolution be transmitted to the Chairperson of the Board of Land and Natural Resources.